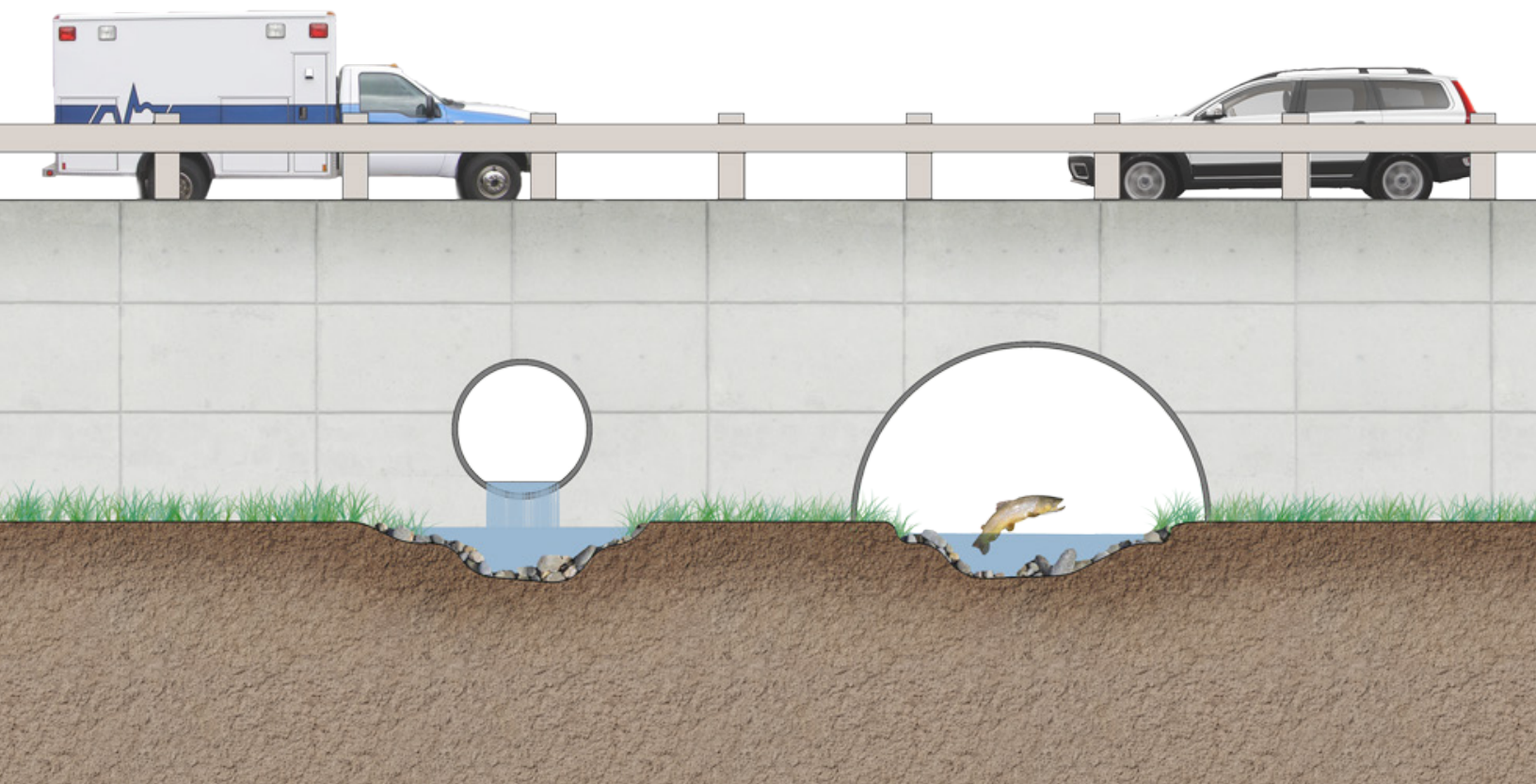


Regional Freshwater Connectivity

Spring 2013 Environmental Studies Senior Seminar
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Executive Summary

Freshwater connectivity concerns the degree to which streams are linked such that not only water, but aquatic organisms, organic matter, and sediment can pass through. Roads and human structures present a potential obstacle to stream connectivity, but stream crossings can be designed to promote healthy passage of water and aquatic species. These designs can also help to improve the resilience of infrastructure, as smaller crossings increase the damage caused by extreme weather events.

Maintaining freshwater connectivity is thus an issue that arises from the intersection of the natural stream network and the built road network. It has profound effects on both ecological health and infrastructure resilience. The issue is of rising importance within the boundaries of the Lake Champlain Basin, where addressing the issue is complicated by the fact that it is governed by three different jurisdictions: New York, Vermont, and Québec.

In partnership with The Nature Conservancy Adirondack Chapter, this report outlines the current frameworks addressing freshwater connectivity in the three jurisdictions, identifies gaps and differences in approaches, and offers recommendations to facilitate a trans-jurisdictional collaborative approach to improving regional fresh-

water connectivity. Through information gathered from regional stakeholders, the report discusses the current policy framework in place in the three jurisdictions that governs efforts to increase freshwater connectivity, as well as the processes by which culverts are funded to be updated, replaced, and repaired.

Four central recommendations to improve freshwater connectivity in the Lake Champlain Basin emerge from the research findings. First, the report recommends a deliberate and comprehensive framing of the issue of freshwater connectivity to stakeholders and the public that makes clear its dual effects on stream species and flood resilience. This recommendation is aimed towards bringing about greater interest and support for the issue by ensuring that it resonates with the greatest number of people. Second, this report recommends greater public access to digestible information about the benefits of culvert improvement and the formation of a regional culvert inventory. The third recommendation focuses on improving regional and transboundary communication to improve collaboration on the issue and leverage more support and resources to address it. This entails the formation of state and provincial steering committees, as well as a transboundary subcommittee of representatives from the three jurisdictions. Finally, the report recommends improved implementation of standards and policies that are already in place that

can be used towards improving freshwater connectivity. In Vermont and New York, these improvements involve greater state oversight and support to towns to better enable them to take advantage of cost-sharing opportunities and meet state stream-crossing standards and best practices. In Québec, improvements involve better implementation and enforcement of policies that address freshwater connectivity. This will facilitate the identification of problem culverts and the prioritization of culvert replacement. These recommendations aim to increase interest in and support for improving freshwater connectivity and facilitate greater transboundary collaboration to address the issue in the Lake Champlain Basin.

1. Introduction

Freshwater connectivity concerns the degree to which streams are linked such that not only water, but aquatic organisms, organic matter, and sediment can pass through. Maintaining connectivity is an issue of rising importance at the sub-watershed level of the Lake Champlain Basin. Roads and human structures present a potential obstacle to stream connectivity, but stream crossings can be designed to promote healthy passage of aquatic species. These designs can also help to improve the resilience of infrastructure, because smaller crossings may impact the geomorphology of the stream and increase the damage caused by extreme weather events. It is important to consider that freshwater connectivity is linked to other issues of sustainability, such as the spread of invasive species, nutrient flows, and water quality. More broadly, as anthropogenic climate change progresses, we can expect stronger and more frequent storm events, and thus economic and social incentives for improved stream crossings will increase. Tropical Storm Irene's devastating effects in Vermont in 2011 made this particularly evident. It is thus of utmost importance that human infrastructure be

designed, updated, and managed with attention to the maintenance of stream connectivity ("Fish Passage and Connectivity..." 2012, p. 1).

1.1 Project Partners

Over the course of our research we worked closely with our community partner Jessica Levine, Senior Consultant of The Nature Conservancy Adirondack Chapter. The Nature Conservancy's mission, "protecting nature for people today and future generations," aligns with the goals of our project. Like The Nature Conservancy (TNC), we are concerned with promoting long-term sustainability and conservation measures. TNC's Adirondack Chapter is currently working to identify priority culverts based on both ecological needs (i.e. fish passage) and community needs (i.e. roads required for hospital access), and has already done so in the Ausable Watershed in New York ("Fish Passage and Connectivity..." 2012).

1.2 A Visual Representation of the Issue¹

¹ See *Technical Appendix (Section 8.4)* for a list of steps used to create maps.

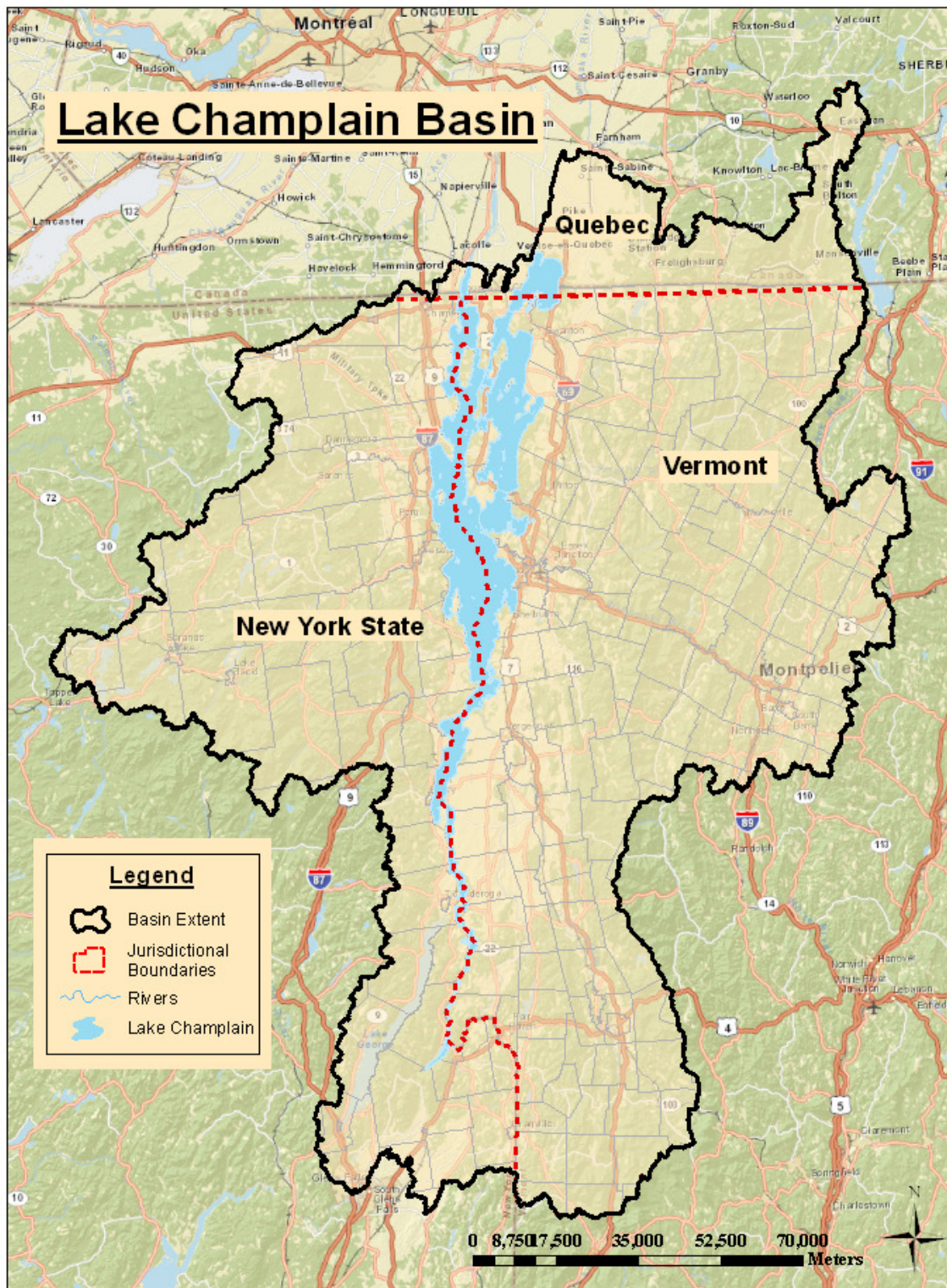


Figure 1: This map shows the various towns and provinces that make up the Lake Champlain Basin, as well as the boundaries separating the three jurisdictions. As later outlined in our Recommendations (Section 5), communication and coordination is necessary across these political boundaries.

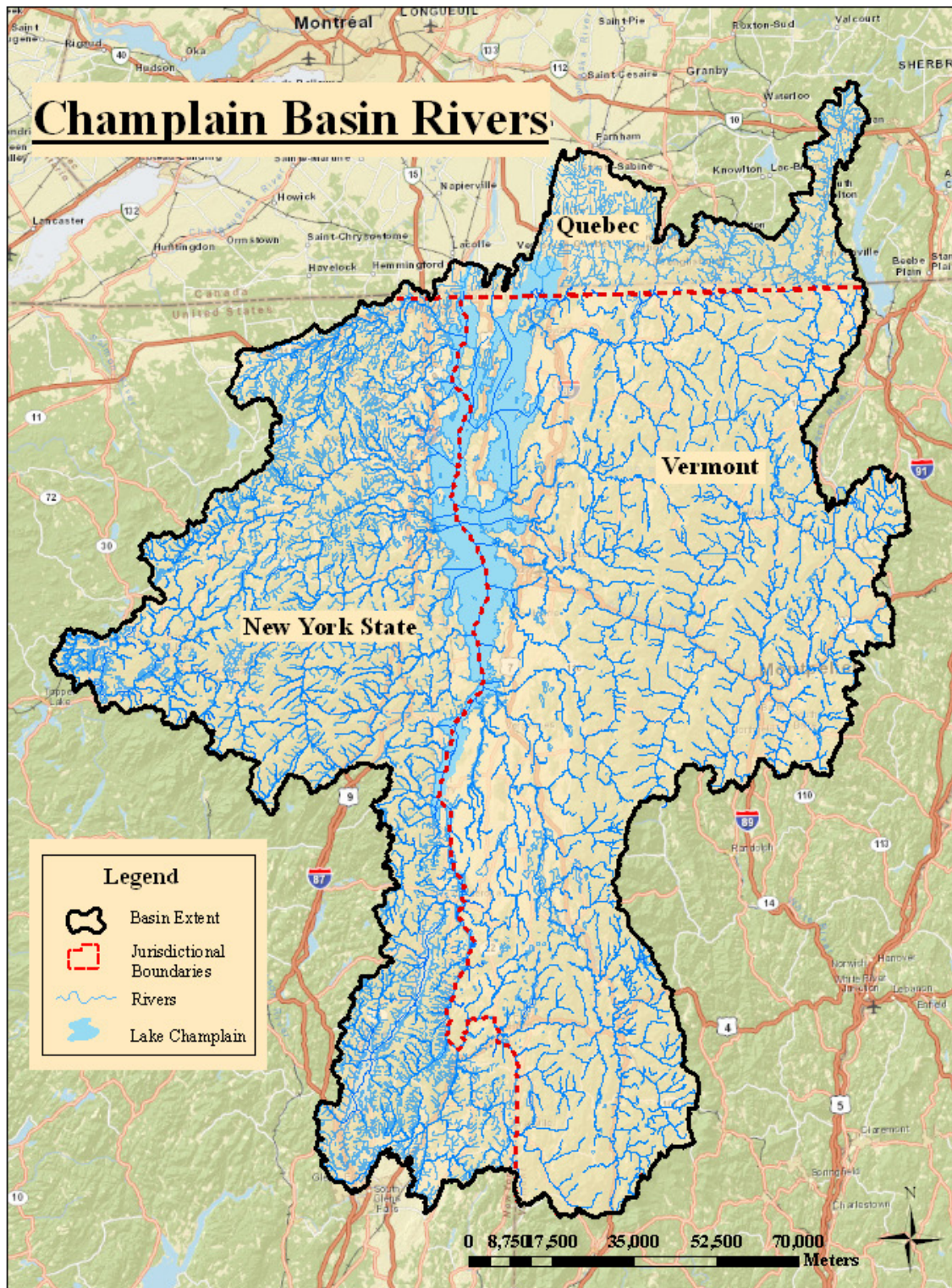


Figure 2: This map shows the rivers of various orders within the Lake Champlain Basin, all of which are important to improve freshwater connectivity and flood resilience.

2. Project Orientation

2.1 The Story of Fontinalis: An Ecological Narrative

The season's first brightly colored leaves are beginning to fall and gather in clumps on the surface of the water as Fontinalis, a brook trout in her first year of life, makes her way inland. After several moons downstream, she is returning to the place where she once hatched from an egg the smooth, translucent white color of a light bulb. When she gets there, she will use her speckled orange tail to dig an imprint in the streambed, about a foot wide, where groundwater can bubble up through the gravel (Pennsylvania Department of Education 2009). As she releases hundreds of eggs into this cradle, a handful of males, bellies scarlet to advertise breeding importance, will gather around her to send out clouds of sperm (Kraft, Carlson, and Carlson 2006).

Most of these ingredients for life will float away in the current, dissolving into so many bubbles as the stream rushes on, particles settling to the bottom to be nibbled by the crayfish that these potential brook trout might have one day eaten. But some of these sperm will find the eggs in the clear stream and meet, cells multiplying furiously on collision. Over the course of two or three moons, these cells will coalesce into the shape of fish fry too big

to be contained in their gelatinous eggs. From the outside, each will resemble a single black eyeball pressed up against the thin membrane of the eggs as if peering into the world (New Jersey Department of Environmental Protection). Sac fry, they will be called, when they emerge, their bodies still bulging with the yellow yolk that nourishes them (Kraft, Carlson, and Carlson 2006). They will hide in the gravel hole Fontinalis made as they slowly absorb the contents of their absurd balloon bellies. Even of those that make it out, most will die, snatched up by bigger fish or unable to find enough food scraps. The ones that survive will follow the same path Fontinalis followed, just last spring, after her own entry into the world. They will grow and travel downstream as she has done, then swim back this way, as she does now. These things Fontinalis knows without knowing them; this is the collective autobiography of her kind.

She journeys for days and nights, maintaining a steady velocity against the current. She travels with the singular drive to send her genetic material into the future, her sleek body fighting against the forces that conspire to stop her, to make her unfit. And then one day, suddenly, she is stopped. Ahead of her, a waterfall: the stream frothing above her head, and several bodies' lengths of air between Fontinalis and the remainder of her trip. This is not an ordinary waterfall. This obstacle was placed there, where it had never been



Brook Trout by Wisconsin Department of Natural Resources

for her ancestors, the ones who wrote this autobiography with their own journeys, traced it on the surface of the landscape with their own taut bodies. Fontinalis swims backwards and then forwards again, struggling to gain the velocity needed to burst out of the water, through the air, over the waterfall, and continue on her way. But the gap is too high, and she can't make it against pouring water, though she tries again and again, gathering momentum for each magnificent leap. Once, she makes it over the top of the waterfall into the mysterious dark tunnel beyond, and lunges forward towards the sun at the other end, but she is weakened by the efforts, and the rush of water ejects her, with an undignified slap, back downstream where she came from. Above her, the stream angrily pours from the corrugated metal tube awkwardly splicing together legs of her journey. Rain begins to fall, staccato on the surface of the water above her, and soon the flow from the tunnel increases to a wild, white surge. Fontinalis will go no

further on her journey. The eggs formed by mechanisms within her body will not meet with the sperm of red-bellied males, and the delicate strings of code written in her cells will die with her, halfway through this ruined pilgrimage.

2.2 The Story of Jim: A Human Narrative

The next morning, as Fontinalis is struggling again in the mouth of the stream crossing, Jim, a human, is running late for work. Waiting at a stoplight, he taps his fingers on the steering wheel and sips his coffee, trying to make his way to the construction site he manages on time. Traffic is heavy this morning, the streets slick with rain still, and his daily migration seems to grow slower each day, his foot alternately slamming from the brake to the gas pedal in his impatience. In this lurching way, he fights his way amongst the rush of cars all heading in their own directions, a living

flow of metal and rubber. The storm last night was nothing to scoff at, but still Jim is not terribly convinced by the global warming doom and gloom that the people on public radio spout when he cruises through the frequencies, looking for something to take his mind off his increasingly late arrival to work.

Jim realizes he has been stopped for several minutes, and he puts his car in park so he can rest his foot. The car ahead of him turns in a dangerous, screeching U to turn around and head back to where it came from. Jim pulls up into its spot, but then he can see what the driver before him saw: nothing. Where yesterday was a road crossing over a stream, and a stream leading to a construction site where people need Jim's guidance to work, there remains only wreckage, a collapsed path worn into nothing by the storm surge that engulfed it overnight. Jim turns around like the car before him, and impatiently waits through several red lights at various intersections before he can get on the alternate route to the construction site that he manages. Today, he will be very late, and each morning for several weeks, he will have to wake in the darkness before his family and children so that he can leave their home in time to take the long, hard way to work. He will do this until the road on his usual route is fixed.

2.3 Project Objectives: Intersecting Connectivities

These two narratives, of Fontinalis the brook trout and Jim the construction worker, do not explicitly intersect, but they are surprisingly connected. Both stories of journeys cut short, of the failings of the built landscape in its intersection with the natural environment, could easily have different endings. A replacement of the culvert that stopped Fontinalis from moving upstream, spawning, and strengthening the gene pool of her species could also have dramatic effects on the way that flooding affects the road that washed out between Jim's house and his livelihood. Connectivity carries an environmental mandate, but also a human and personal one: our infrastructure will be stronger and more cost-effective while also minimally disrupting the passage of aquatic organisms such as brook trout. While culverts may seem like unexciting spaces under the road, there are two groups of stakeholders with great interest in their upgrades: people interested in enhancing ecological health, and people interested in improving the flood resilience of infrastructure.

Compared to many conservation concerns today, the issue of maintaining freshwater connectivity in the Lake Champlain Basin is unusual in that it does not appear to be a battle between human interests and nature. In this case, the wellbeing of

the environment is deeply entwined with that of local communities; improving freshwater ecosystem health improves the resilience of human infrastructures. The nature of this problem allows better connectivity between people and communities, and it reduces dangerous washouts that could prevent access to emergency services after extreme weather events. The economic and practical aspects of the issue offer a unique opportunity to connect with stakeholders who, like the fictional Jim, may be skeptical of conservation efforts and unwilling to expend money and time to mitigate the effects of an issue like climate change. Poor connectivity can negatively affect the physical infrastructure of a town, which residents interact with daily, regardless of their perspectives on the environmental forces involved.

With this link established, the goal of this project is to incorporate all motives and perspectives into an overall understanding of how we can act to improve connectivity, both in freshwater networks and in the parallel human networks. If everyone is in favor of improved culverts, then it would seem that there are no barriers to the replacement and upgrades; however, policy is not yet streamlined enough to handle this problem. Further complicating connectivity in the Lake Champlain Basin is the fact that the issue transcends boundaries established on the landscape--both state and national, in this case. There is currently a lack of connect-

edness and communication even among those who are pushing for connectivity itself.

With this in mind, our project had four main objectives. First, this report outlines the current frameworks addressing freshwater connectivity in the three jurisdictions of New York, Vermont, and Québec. We then assessed the existing policies and practices, and identified gaps and differences in these approaches. Using this analysis and input from previous case studies and interviews with stakeholders, we made recommendations that will facilitate a trans-jurisdictional collaborative approach to improving regional freshwater connectivity. Ultimately, we designed a toolkit of next steps (see Appendix Section 9.5), which can be referenced by agencies and individuals working to promote connectivity and resilience. We intend for these recommendations to be applied in an integrated way across the Lake Champlain Basin and expect that they will greatly improve the efficacy and thoroughness of future efforts to improve the ecological and human connectivity in a transboundary way.

2.4 Report Roadmap: A Recommendation-Based Analysis

This report specifically examines the policy framework currently in place in New York, Vermont, and Québec that governs efforts to increase freshwater connectivity and improve flood resilience in the Lake Champlain Basin. It also considers the processes by which culverts are funded to be updated, replaced, and repaired. After gathering this information from stakeholders in the three jurisdictions, we identified opportunities to facilitate a trans-jurisdictional collaborative approach to improving regional freshwater connectivity. This report is framed around our four central recommendations stemming from our research findings. First, we recommend a deliberate and comprehensive framing of the issue of freshwater connectivity to stakeholders and the public that makes clear its dual effects on ecological health and infrastructure resilience. This recommendation is aimed towards bringing about greater interest and support for the issue by ensuring that it resonates with the greatest number of people. Second, we recommend greater access to digestible information about the benefits of culvert replacement and the formation of a basin-wide culvert inventory. Our third recommendation focuses on improving regional communication to improve collaboration on the issue and leverage more support and

resources to address it. This entails the formation of state and provincial steering committees, as well as a transboundary subcommittee of representatives from the three jurisdictions. Finally, we recommend improved implementation of standards and policies that are already in place that can be used towards improving freshwater connectivity. In Vermont and New York, this involves greater state oversight and support for towns to better enable them to take advantage of cost-sharing opportunities and meet state stream-crossing standards and best practices. In Québec, this involves improved implementation and enforcement of policies that address freshwater connectivity. The report outlines these recommendations to improve freshwater connectivity in greater detail as well as the research findings that inform them.

3. Study Precedents

3.1 Case Studies of Successful Connectivity Efforts

Based on successful past efforts related to connectivity initiatives throughout the US, we have amassed a list of “Best Practices” to benefit freshwater connectivity. These past case studies have informed our recommendations in the Lake Champlain Basin.

Wisconsin’s Green Bay Watershed (TNC initiative)

The Nature Conservancy’s initiative to improve stream connectivity for Northern Pike in Wisconsin’s Green Bay Watershed successfully organized workshops for road engineers and resource managers

on design and implementation of effective culverts (“Helping Northern Pike Cross the Road” 2012). This helped to confront the issue in a direct way. The initiative was also successful in targeting a certain species of fish (northern pike) to help gain support from fishery interests, which in turn helped mobilize action and lobbying to raise funds for the culvert renovation effort.

We applied this idea to the Lake Champlain Basin and reached out to representatives of a niche group, Trout Unlimited (TU), which works to improve trout habitat. They proved extremely helpful in outlining the current policy framework and major shortcomings.

River and Stream Continuity Project: A UMASS & TNC Collaboration

The Nature Conservancy worked alongside the University of Massachusetts



Connecticut River by Timothy Clough

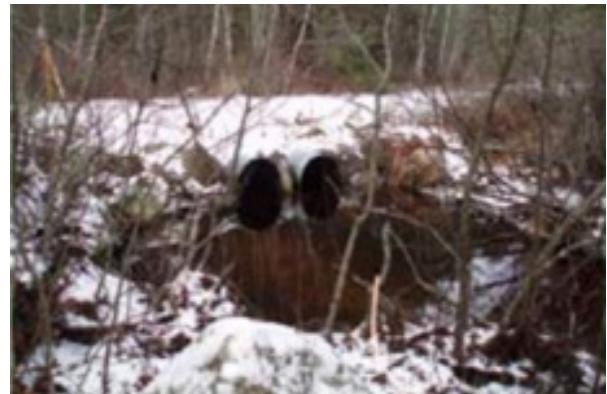
to found the River and Stream Continuity Project. They developed a set of standards for stream crossings, which they applied to identified priority crossings (Jackson 2007, p. 66).

As TNC's Adirondack Chapter has already identified priority crossings within the Ausable Watershed, we see the potential for them to build upon this effort by collaborating with a local university to develop state standards for stream crossings. Similarly, within the Lake Champlain Basin, University of Vermont graduate students in environmental studies could fulfill that consultation role in the jurisdiction of Vermont, while students of environmental studies at schools such as Université du Québec à Trois-Rivières could serve that purpose in Canada.

Maine NRCS Culvert Replacement

Maine's Natural Resources Conservation Service (NRCS) conducted a study on the economics of culvert replacement in 2006. They worked with Project SHARE (Salmon Habitat and River Enhancement) to replace stream crossings that presented an obstacle to fish passage. They performed an economic analysis to compare long-term costs of routine culvert maintenance and repairing inadequate culverts versus investing in a properly-sized arch culvert (see images at right). According to their findings, the average maintenance cost for an existing culvert is estimated at

\$600 per year. Existing 2.5' round culverts, those typically classified as "small" and most likely to be labeled as problem culverts, have a replacement cost of \$3,780 every 10 years (in 2007 dollars). The one-time installation cost for an ecologically-sensitive culvert is \$28,189, with virtually no maintenance costs (Long 2010, p. 2). The NRCS's finding that preventive culvert replacement is more cost-efficient than de facto replacement (ie. post-storm event) guides our recommendations in Section 5.



Pictured above are inadequate 2.5' round culverts (top) and a properly-sized arch culvert (bottom). Photos by Ricky Hall, NRCS.

Case Studies Presented at the Upstream-Downtown Symposium

The “Upstream Downtown Symposium,” which took place on April 8, 2013 in Burlington, Vermont, presented efforts regarding the education of the public on the importance of rivers as both economic necessities and cultural symbols. This conference addressed the issue of establishing boundaries between humans and the natural environment and discussed ways to make the relationship more stable. There were relevant examples from within regions of the United States, as well as helpful case studies across international boundaries from Europe. Presented below are some of the findings from the conference.

Regarding the Great Mississippi Flood of 1927, the “Dutch Dialogue” was put into place, which was a set of workshops involving Dutch engineers, urban landscape designers, landscape architects, and city planners as well as soil/hydrology experts. It was a multidisciplinary and international approach to water management, flood mitigation, as well as landscape architecture in response to the New Orleans catastrophe. The “Dutch Dialogues” strive for the recreational use of waterways, as cities reinvent their relationship to the waters. Dutch policy relies on the idea of “living with the water,” which accentuates the notion that both safety and human gain are possible (Meffert 2013).

In Europe, efforts in public communication have proven to be successful. Bettina Wanschura emphasized that knowledge about the river systems was an integral part of addressing the issue, and therefore of creating a pathway for effective management plans. The framework in Europe, as she states, regarded the culture of dialogue and process—that is, effective communication. One example that she presented was that of the River Dialogues. This program incorporates real and online participation, so that all people at different levels of influence are able to participate. The purpose of this program was to first provide knowledge of the importance of rivers, thus creating awareness, and further integrating consultations regarding interest, concerns, and future visions. In order to implement this idea, the program engaged stakeholders at the local, state, and federal levels in an interactive process of discussion, and small group presentations. As some findings suggested, people wished to be more informed, as they were eager to participate and learn more about the process. Furthermore, professional facilitation of this process seemed to be emphasized.

Another example in Europe involved flood management plans, as an effort to bring participation at all different levels. There were pilot projects conducted with the close cooperation of governmental units and landowners. Discussions were based on the catalog of measures, how

to pinpoint the most risk-prone areas, as well as the methodology of how to assess these findings. As a takeaway, possible plans were to involve information events in the different regions, online tools for all areas to assess, and presentations on the different findings.

As the last example, Wanschura accentuated the cultural connection to the land's rivers. There are River Festivals that occur in Europe which allow for a sense of connection to these important features of the landscape as well as society.

3.2 Current Scientific Literature

USFWS Guide

The U.S. Fish and Wildlife Service has developed an extensive guide to stream simulation entitled "Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings." Stream simulation is a road-stream crossing design method to preserve the continuity in stream systems and allow unrestricted movements of aquatic species. Stream simulation structures mimic the slope, structure, and dimensions of the natural streambed. In addition, the water depth and velocity should be similar to those of the natural channel. The guide emphasizes the importance of focusing on maintaining the ecological health of the ecosystem as a whole, rather than on

one particular species. It acts as a step-by-step model for land and road managers to design stream-crossing structures that preserve or enhance ecological health, and includes strategies for assessing the watershed as a whole, assessing specific stream-crossing sites, and designing road-stream crossings that are specific to the site's characteristics. The report also includes recommendations for decisions on structure type, materials, and contract recommendations and outlines strategies for stream-crossing construction to reduce habitat destruction and help practitioners avoid common mistakes. This information is presented to improve the understanding of land and road crews of the importance of maintaining ecological health at road-stream crossings and building stream-crossing structures that facilitate species mobility and minimize ecosystem disruption ("Stream Simulation" 2008).

4. Framing The Issue

Before they take action to solve a problem, stakeholders must fully understand it. For this to happen, those with access to information need to communicate it and frame the issue in a thorough and compelling way. Part of this may involve the construction and development of narratives that people can identify with, such as the two stories that introduced this report. In the course of our research, our team discovered notable differences in the way that people in different parts of the region frame the issue of increasing connectivity and flood resilience in the Lake Champlain Basin. What we have identified already as unique about efforts to improve freshwater connectivity through better stream crossings is that they often coincide with efforts to improve flood resilience. It's not man versus nature, as many environmental issues appear to be framed, but an interaction where both man and nature can clearly gain from the same actions. However, across the jurisdictions, the narratives that surround this issue need to be refigured and developed further. Thus, we recommend that current outreach, publicity efforts, and education be altered and improved to more fully encompass an understanding of what's at stake both ecologically and humanistically.

In the province of Québec, this means

that the issue needs to be viewed not only as an ecological priority, but also as something with real economic and human consequences for the built infrastructure. Especially in Vermont, it seems that post-Irene, efforts to protect human infrastructure have gained more attention than the aquatic species passage efforts. This was apparent in the efforts to gain the funds needed from the Federal Emergency Management Agency (FEMA) to help repair damage done by Irene and to minimize the risk of future washouts. In all three jurisdictions, it is clear that by framing the issue as simultaneously important for human communities and for ecosystem health, we will gain more interested stakeholders with valuable resources to add to the work.

4.1 Current Policy and Framing Recommendation for Québec

The current framework in Québec focuses on replacement rather than prevention. There are currently no programs in place on the provincial or municipal level that focus specifically on culverts and stream crossings (Nilo 2013). Canadian municipalities tend to replace damaged culverts using the same technology and sizing as before, perpetuating a cycle of damage and replacement. Québec contains 21 Regional County Municipalities (MRCs) that manage land use and establish waste management and fire protec-

tion services (Imhof 2013). These MRC's, groupings of municipalities, are below the provincial government, which answers to the federal government.

The main legislation governing replacements or upgrades of culverts in Canada is The Fisheries Act, which was first passed in 1985 and focuses, aptly, on the respect and protection of the nation's fisheries (Nilo 2013). Regulations made under the Fisheries Act include Aboriginal Communal Fishing Licenses Regulations, Fish Toxicant Regulations, and Foreign Vessel Fishing Regulations, among many others. While there are no explicit regulations formed regarding culverts and stream crossings, under the Fisheries Act it is established that, "No person shall carry on any work, undertaking or activity that results in the harmful alteration or disruption, or the destruction, of fish habitat." The Act also contains an article about the enforcement and punishment for those that do harmfully alter or disrupt fish habitat: "Every owner or occupier of an obstruction across or in any stream who refuses or neglects to provide and maintain a fish-way or canal in accordance with section 20, to install and maintain fish stops or diverters in accordance with subsection 21(4) or to provide for a sufficient flow of water and the free passage of fish in accordance with section 22 is guilty of an offence punishable on summary conviction..." and liable for heavy fines. Because certain stream crossings qualify as obstructions, the Act

technically gives the federal government of Canada the authority to force the owner of a stream crossing (whether it is a province, MRC, or private landowner) to remove, alter, or upgrade a culvert that impedes fish passage (Nilo 2013).

One example of The Fisheries Act in action made news in February 2013. A Québécois construction contractor was convicted, after pleading guilty, of six charges of the "HADD" (harmful alteration, disruption, or destruction of fish habitat) identified by the Fisheries Act. He was fined \$165,000 in damages, of which \$150,000 would go directly to promoting the protection of fish habitat in the area where he committed the offenses. According to the Department of Fisheries and Oceans' account of his violations, "during installation of culverts and bridge construction, machinery directly crossed through watercourses. Significant quantities of sediment and the resulting turbidity contributed to altering more than 26,822 square meters of fish habitat used particularly by brook trout, a species highly prized by recreational fishing enthusiasts" (Fisheries and Oceans Canada 2013). It seems that this case was a high priority not only because of its huge scale, but also because it occurred in the Réserve Faunique des Laurentides, a pristine wildlife reserve popular for fishing and camping.

It is clear that the Fisheries Act has the potential to be a great tool for promoting freshwater connectivity in Canada,

and that there is a strong understanding of culvert design to help aquatic species passage. In 2010, the Department of Fisheries and Oceans released a document called “Best management practice for the design and construction of permanent culverts less than 25 metres” that provides criteria for the healthy ecological design of stream crossings of that specific size. This attempts to clarify how those implementing culverts (usually either provincial or municipal governments) can follow the regulations laid out by the Fisheries Act: “Section 35...stipulates that it is prohibited to carry on any work or undertaking that results in the harmful alteration, disruption or destruction (HADD) of fish habitat, unless the HADD has been authorized by DFO. If you abide by the conditions and implement the measures described in this document you will be acting in accordance with subsection 35(1) of the Fisheries Act.” This is a technical document which concisely explains the restrictions and regulations that stream crossings must meet according to their design (arch, low slope, stream simulation, or culvert with weirs). Of the possible designs, “DFO favours the use of a clear span culvert (e.g. arch culvert) because it makes it possible to maintain natural flow conditions and avoid encroachments on fish habitat, by preserving the physical characteristics of the existing stream, i.e., the substrate, slope and width.” For all styles of culverts <25 m, this document clearly and concisely out-

lines the ways in which ecological impact can be minimized, including what time of year is appropriate for construction, how to prevent excessive sediment from entering the stream, and effective use of baffles to break up the flow of water through a culvert to lower water velocity and improve fish passage. Ultimately, this document makes it clear that Québec is effectively designing communication with people who are building stream crossings, and it is distributing information that will help promote fish passage through the construction of better culverts. Further, the DFO’s knowledge of how best to implement culverts in a safe ecological way that complies with this Act is well-developed.

All of this framework demonstrates real attempts to educate the public about the importance of fish passage and freshwater connectivity as an ecological concern. However, conspicuously absent from this culvert recommendation document, and from much of the Canadian literature regarding culvert upgrades, is the concern for the effects of extreme weather events on infrastructure that is so prominent in NY and VT literature. While our scope may be biased by those we spoke with, it is clear that aquatic species passage is more of a factor driving research than economic and human-built infrastructure concerns. Two particular projects in the Research and Development section of the Transports Québec, highlighted by our interviews with Pedro Nilo, a biologist for the Canadian

federal government, focused specifically on culverts. However, though Transports Québec should likely be concerned with flood resilience of the built infrastructure, neither of these projects tackles that issue. One of them examines the effects of culvert material and size on a group of brook trout over time; the other attempts to determine flow capacity of culverts depending on a variety of factors (“Modélisation de la capacité de l’omble de fontaine à franchir les ponceaux” 2012; “Conception de ponceaux” 1998).² While this second research project concerning culverts could connect to promotion of better design based on flood resilience, its research abstract does not mention storm events or culverts’ role in washouts, and further, it is over ten years old. The fact that Mr. Nilo thought of these two particular projects when considering relevant research highlights the framing issue we have identified in Canada: the trout connectivity work is recent, while the work done on flow patterns in terms of the human infrastructure is a decade old and only tangentially related.

This concern is not limited to the province of Québec. Ontario has its own, more extensive legislation regarding culvert upgrades and connectivity, but again, this is largely focused on the ecological concerns associated with poor stream crossings. Under Ontario’s Drainage Act,

“The engineer in the report shall provide for the construction, enlargement or other improvement of any bridges or culverts throughout the course of the drainage works rendered necessary by the drainage works crossing any public road or part thereof. R.S.O. 1990, c. D.17, s. 17.” This could be promising in terms of focusing on the improvement of structures for the promotion of extreme weather resilience, but according to Manson Barton, the Drainage Superintendent working under this Act at the municipal level, the issue is still considered an environmental one. Culverts and bridges are classified based on the kinds of water flow and species habitat they are affecting: whether it’s cold or warm, shallow or deep, permanent flow or dry during certain seasons, and whether it supports key predators (Barton 2013). In order to replace a culvert, Barton is required to gain permits from the Ministry of Natural Resources, which works to enforce the Endangered Species Act; from the Department of Oceans and Fisheries, if the crossing could potentially affect the habitat of certain aquatic species; and from the conservation authorities of Ontario (Barton 2013). These conservation authorities are self-described as “local watershed management agencies that deliver services and programs that protect and manage water and other natural resources in

² To view the abstracts of these projects, go to:

http://www1.mtq.gouv.qc.ca/fr/projet_recherche/description.asp?NO_PROJ=R291.1P1

http://www1.mtq.gouv.qc.ca/fr/projet_recherche/description.asp?NO_PROJ=R656.1

partnership with government, landowners and other organizations” which are formed and invested with their power by the 1946 Conservation Authorities Act of Ontario (“Natural Champions” 2009). The involvement of these three actors in stream crossing replacement demonstrates a recognition of the far-reaching ecological implications of stream crossings. However, the lack of input from those who are working to build more resilient structures from a human perspective suggests a fundamental understanding of the issue as first and foremost an ecological one.

This increased interest in the ecological problem over its infrastructural counterpart could be due to a lesser impact from recent extreme weather events in Québec compared to Tropical Storm Irene’s devastating effects in Vermont. When asked about storm event readiness and upgrading stream crossings preventively, Christian Poirier, a hydraulics and culvert expert working for the Québec Transport Ministry, explained, “It would have to be a really large storm to receive federal funding.” He could not think of any examples of such a storm or such allocation of funding in recent memory (Poirier 2013). However, Québec was negatively impacted by the flooding of the Richelieu River in 2011, and we recommend that this be used to leverage more support and interest in stream crossings at the municipal level. The Lake Champlain Basin Program released a comprehensive document called “Flood

Resilience in the Lake Champlain Basin and Upper Richelieu River” in March 2013 which notes, “The flood events of 2011 left a profound and lasting impact on the watersheds of Lake Champlain and the Richelieu River Valley and their residents. Lake Champlain reached flood stage on April 13, 2011 and remained above this level for 67 days until June 19, 2011....The Richelieu River, Lake Champlain’s outlet, was also greatly affected by the high water levels, and several communities along the River were severely impacted by flooding for the two-month duration of the spring 2011 events.” A conference was held to discuss measures that could be undertaken to prepare for future flooding events more effectively, and the results of these discussions were published in the document. Our research team highly recommends that anyone interested in connectivity and resilience in the Lake Champlain Basin read this report, as it does an excellent job of combining the ecological and human concerns to make strong recommendations, some of which coincide with our own. At the very least, this report is evidence that Québec does have a strong vested interest in preparing their stream crossings for potential flood events, and that proper framing of the issue to be about human and economic concerns as well as ecological, as exemplified by this document, has the potential to effect broader change.

It is clear that the policy in place in

Québec and other parts of Canada frames the question of better culverts as an environmental issue (protection of fish passage) and not as an economic or human concern. Pedro Nilo, a Biologist at the Canadian Department Of Fisheries and Oceans, said that in his experience, roughly half of municipalities have an authority figure with an interest in culvert upgrades and connectivity, which makes the boundaries between them frustratingly relevant in the case of connectivity. Nilo's own interests, as a biologist, mainly lie in the natural systems at play and not the built, human systems. But with climate change likely to increase severity and frequency of storm events, and with environmental issues often pigeonholed or even cast as the enemies with other causes, it is extremely detrimental to allow this issue to be considered solely ecological. If Canada's federal policy and Québec's provincial policy could relate to municipalities on their terms--funding and connectivity for their town, rather than only for fish--and highlight the dangers that undersized culverts pose during storm events--as well as the economic benefits of upgrading culverts rather than simply replacing them with the same size (or ignoring them until crisis)--then the landscape would be much more conducive to the efforts to improve freshwater connectivity.

4.2 Current Policy and Framing Recommendation for NY/VT

The States of Vermont and New York have structures in place that both promote freshwater connectivity for ecological reasons and that work to reduce the hazards posed by flooding during extreme storm events. Though the state of current policies regarding culvert upgrades in New York and Vermont is less of a concern than it is in Québec, stakeholders here could still benefit from framing the issue more broadly. Especially after Tropical Storm Irene, there has been much more interest in storm event readiness and flooding prevention measures than in the ecological benefits of culvert upgrades. This is more true in Vermont than in New York, but applicable in both cases, as the state of New York has also been examining its storm readiness in recent months due to the effects of Hurricane Sandy especially on its coastal areas.

Most prominently, interactions with FEMA and gaining funds to repair damage after storm events have been highly publicized in Vermont. In addition to providing financial assistance for infrastructure replacement and rebuilding after major disasters or emergencies, FEMA also has funding opportunities for hazard mitigation measures taken before the event and during the recovery process ("Multi-

Hazard Mitigation Planning” 2013). A major breakthrough in hazard mitigation for culverts was recently made in Vermont following the damage from Tropical Storm Irene in 2011. Initially, during the recovery process, FEMA denied requests for additional funding to enlarge and upgrade destroyed culverts to meet the Vermont standards adopted in 2006 outlining that culverts should be larger, arch-shaped, and have natural streambeds (“Vermont, FEMA Clash over New Culvert Funding” 2013). FEMA claimed that the costs of upgrading were not eligible for Public Assistance Funding on the grounds that the state had not uniformly enforced its culvert standards. The town of Townshend replaced a destroyed 14-foot diameter corrugated metal culvert with an open bottom, concrete arch box culvert spanning the full width of the stream, and after FEMA’s initial ruling, the town was expected to cover the \$100,000 cost difference. With the support of Vermont’s Public Assistance Office and the Agency of Transportation, the town appealed FEMA’s decision, and FEMA ruled that the culvert upgrade was eligible as a hazard mitigation measure (“Gov. Shumlin...” 2013). This ruling is an important precedent that could allow dozens of other Vermont towns to qualify to be eligible for full reimbursement for culvert hazard mitigation projects, and towns could collectively receive an additional \$8 million from FEMA for culvert upgrades (“Vermont, FEMA Clash over New Culvert

Funding” 2013).

Vermont has now undertaken efforts to fix problems with its current permitting system that prevented the state from receiving the maximum possible monies from FEMA post-Irene. To this effect, it recently revised its Stream Alteration permitting procedure so that it can more easily receive the full extent of FEMA funding for replacement after future storm events. This was an attempt to make permitting more uniform across the state, and to allow townships to replace stream crossings that they identified as highly vulnerable (i.e., posed a risk to public well being and/or threatened to collapse in the next 72 hrs.) without following all of the environmental standards and contacting the state for permission. While this may seem counter intuitive, a public meeting held in April for comment on the new permitting requirements clarified that currently, many townships did not heed these standards when upgrading stream crossings in emergency cases. Because the state of Vermont understood that these were emergency measures, they did not punish these townships, and thus the standards became lax because culverts could be replaced even in non-emergency situations without paying close attention to the necessary permitting process. Now, with revisions and new categories of urgency in place, only the truly emergency replacement measures (imminent danger within 72 hrs.) can be undertaken without permitting; other projects will be expected to

fully comply with environmental standards and will require permitting, which in some cases will include engineers' reports on the proper size and shape of the culvert based on the geomorphology of the stream.

While post-Irene replacement and funding from FEMA is a high priority for Vermont communities and should remain as such, it is still important to recognize that freshwater connectivity can be improved and ecological concerns met at the same time as human flood resilience is increased. To this effect, our group recommends that Vermont and, to a lesser extent, New York, focus not only on preventing future flooding, but on the positive consequences of better culverts ecologically. This is not to say that the approach right now is not valid; important work may "get done" under the umbrella of flood resilience. But many resources will not be allocated to that fight, and so it will take much longer and be less efficient to view it as a post-Irene struggle for funds and a protection of human needs without considering others who may also be working for the same goal. Currently, the private group Trout Unlimited has been using its monetary resources and access to grants to promote connectivity and habitat for the preservation of the trout species that are recreationally fished by its constituent donors. But this organization does not work in conjunction with any of the municipalities that are trying to improve stream crossings for the sake of their own

community's safety and readiness. If these forces could be combined, all would benefit.

4.3 Framing the Issue: Final Words

Ultimately, the recommendation to reframe the issue and to encompass all stakes, both ecological and infrastructural, will be most effective if it results in the formation of more private groups that are transboundary not necessarily geographically, but in terms of interests. Currently, environmental non-profit groups such as Trout Unlimited (which exists separately in the U.S. and in Canada) focus on aquatic species connectivity, while municipalities and local communities struggling to get funding focus on their own roads' resilience. Our community partner, The Nature Conservancy, strives to unite these interests under the umbrella of one organization. But if there were more groups that combined these interests--for example, people from towns heavily affected by washouts working as part of the same private group as recreational fishermen wanting to improve culverts that impede fish passage--then surely resources would be pooled more easily and change effected on a broader level. This idea will be discussed in more detail in later recommendations, particularly the suggestion to

form a steering committee. Regardless of the specifics of how it is carried out, it is imperative to the goals of improving connectivity and flood resilience that everyone understands and sees these as equal and synergistic priorities.

5. Improving Public Education

In order to implement a reframing of the issue in all three jurisdictions, it is necessary to ensure that information is easily accessible to all stakeholders through improved public education. We hope that through access to quick information and improved education for municipalities we can generate support for connectivity at the ground level.

5.1 Municipal and Public Education

Eliminating Cost-Efficiency Misconceptions

Studies have repeatedly found preventive culvert replacement to be more cost-effective than routine maintenance and post-storm replacement, but this information has yet to be made available to stakeholders in an effective manner. Publicizing this information to municipalities in the Lake Champlain Basin would likely change current practices regarding culvert replacement.

In addition to a study conducted by Maine's NRCS (see Section 3.1), Michael Simpson at Antioch University has conducted research on the economic benefits

of taking preventive measures to promote freshwater resilience. In his report outlining the cost of resilient infrastructure in Durham New Hampshire, he drew several conclusions. First, and not surprisingly, he found that many of the existing culverts would not survive an extreme weather event due to being undersized for high stream flows. Second, he found that standard policy in Durham (and most other towns in New York, Vermont, and Québec) is to replace culverts with similarly sized culverts after a flooding event. Third, Simpson calculated the cost of replacing all priority culverts in Durham with properly sized culverts that promote connectivity. He found that the total upfront price tag for this project would be about \$150,000 more than the "business as usual" scenario. However, if and when another tropical storm hits Durham in the future the cost of the "business as usual" scenario will rise to \$1,000,000 or more. Simpson's analysis demonstrates that upfront cost pays off long term, but the challenge is to convince policymakers that preventive action is worth it. (Stack, L., M.H. Simpson, and T. Crosslin 2010). This analysis allows us to make a strong economic argument for preventive measures instead of standard repair procedures, especially if we can convince funding sources that they can save millions of dollars doing so.

The type of culvert dictates its average lifespan. Highway supervisors in the Adirondacks estimate that corrugated metal

pipe culverts have a lifespan of 15-30 years, while the NYS DOT estimates that concrete box culverts last upwards of 70 years. These lifespans should be taken into consideration by future researchers who may, with access to the necessary data, perform a cost-benefit analysis for preventive culvert upgrades in the Lake Champlain Basin.

Voluntary Incentives

We encourage action plans and voluntary incentive programs to be developed at the municipal level. Currently, yearly action plans are developed at the transboundary level, such as the 2013 Lake Champlain Opportunities for Action Plan, while voluntary incentives only exist at the state level. Voluntary incentives used to encourage environmental activism in this arena are presently limited to the Governor's Awards for Environmental Excellence ("Vermont Governor's Awards..." 2013).

The Vermont Agency of Natural Resources has a number of these governor's awards it sends out each year in various categories such as "Environmental Justice and Sustainability" and "Earth Stewardship and Resource Protection." These reward groups, individuals, and businesses engaging in projects with measurable and direct benefits to air, soil, or water resources protecting ecosystems of fish, wildlife and human communities. These have shown mixed success; we suspect incentives at

the town level would be more effective and, based on interviews with stakeholders, many express the same idea.

Groups often face high up-front organizing costs that prevent them from taking initial action and hamper sustained action. In this case, voluntary incentives for preventive measures to improve culvert designs and stream connectivity are weakened by the fact that the monetary benefits these awards offer their recipients are not immediate enough to motivate action. They are awarded only on a yearly basis, and many groups are not even aware of their existence. One main reason such awards cannot be publicized more effectively and allocated more frequently to encourage environmental protection is the challenge of monitoring and reporting from afar. If the responsibility of monitoring and conducting publicity campaigns could be shifted to local governments, monitoring costs would be lower and issue salience higher. Public outreach can most efficiently occur at the local level since getting people to care about and directly act on issues is dependent on how salient and visible the issues are to them ("Community Culture and the Environment" 2002).

In the case of transportation structure implementation, the process for approving culvert renovation and dam removal is convoluted, especially when it involves federal roads and the federal government. Voluntary incentives are a great option since they streamline the political

process, in turn making it more appealing for firms and organizations to take action. Reforming the political process at the federal level would be the best option, but until federal agencies like FEMA can revise their funding policies to better motivate municipalities to take preventive measures to improve freshwater connectivity (i.e., prevent flooding that could damage infrastructure rather than clean up post-disaster), voluntary incentives are the best option we have found. Currently, the VT DEC is working with the governor on these programs. While monitoring and enforcement could be seen as a potential issue, adherence would be more easily enforced and voluntary actions more easily rewarded at the local level. Further, such a program would likely receive bipartisan support as the state-run program already does, since liberal environmentalists and conservatives wary of government intervention alike could agree that giving more power to local governments in this matter is beneficial.

5.2 Increasing Access to “Easy Information”

Culvert Prioritization

Establishing an online culvert inventory that is accessible to the public is a feasible and necessary first step to getting the public involved in connectivity efforts.

Getting all culverts mapped out across all three jurisdictions is a prerequisite to then pinpointing problem culverts, since culverts can only be prioritized once they are all accounted for.

One major obstacle to coordinating transboundary communication is the fact that existing culvert inventories in the three jurisdictions are marked by varied levels of comprehensiveness (Castle 2013, p. 44). At one end of the spectrum is Vermont’s inventory, accessible to the public via the Vermont Center for Geographic Information (VCGI), which lists all culverts in the state in the metadata of a file called “Trans_Structures.” In New York, besides an extensive inventory that has been conducted within the geographic limits of the Ausable watershed, only locations of large culverts have been mapped, meaning those spanning 5 to 20 feet in length. This provision by the New York State GIS Clearinghouse will not be very effective in improving connectivity; it is small culverts that are more likely to create an obstacle for aquatic species passage and more likely to wash out in the case of an extreme weather event. As for Québec, the province currently does not have any sort of culvert inventory that is accessible to the public.

Once all culverts are successfully inventoried, states and provinces can move toward prioritizing these culverts in a manner similar to what has already been done by TNC’s Adirondack Chapter

in the Ausable Watershed of New York (“Fish Passage and Connectivity...” 2012). TNC conducted an extensive inventory in the watershed, then prioritized culverts from that inventory based on how much of a problem for connectivity each culvert presented. They ranked culverts by need to rebuild, for ecological reasons and/or flood resilience reasons. They also created a standardized planning process to guide the replacement of those impassable to fish species or those posing a risk to human infrastructure in the case of an extreme weather event. To then make this information more accessible to the public, they created a clickable online map of culverts categorized by urgency of the problem. Michelle Brown, the project lead, said “Based on our current work, we have determined which areas can achieve the most ‘bang-for-the-buck’ in terms of meeting ecological, social, and economic goals, and now we need to focus on these places to build their resilience (“New York Culvert Inventory: What Lies Beneath” 2013).”

A similar user-friendly interface and accompanying cost savings calculations can be created specifically for the Lake Champlain Basin in the future, but only if all culverts are inventoried and prioritized first. Using spatial planning software, we created a map to show what this web interface might look like when zoomed out

(see Figure 3). To account for the gap in data currently available to the public via existing online inventories, we pinpointed all locations where streams intersect roads. Towns darkest in color have the highest incidence of stream crossings, while those lightest in color have the lowest stream crossing density (see Figure 3). Creating a similar classification system but designed specifically for culverts rather than under the broad label of “stream crossings” (excluding bridges) would allow people to see which towns in the basin would benefit most from giving more attention to issues of culvert replacement and retrofitting, and particularly how their town compares in terms of the incidence of problem culverts. Ideally we’d like to allow web users to zoom in on individual towns to view culverts at one more level of detail, seeing which culverts cause the most problems in their immediate neighborhood. Web users could also view the benefits of preventive action to replace individual culverts in dollar value, with projections based on average costs of culvert replacement.³

Upon virtually recognizing the relevance of this issue to their hometown and understanding the benefits of action in easily-digestible economic terms, residents of the Lake Champlain Basin would likely become more engaged in local

³ *Average costs of culvert replacement have been estimated by Maine’s NRCS (see section 3.1 for detail on cost projections based on this study) as well as Michael Simpson at Antioch University.*

culvert policy. The issue of freshwater connectivity would impact people in a personal way, and they may be more motivated to find creative and effective solutions. To facilitate public involvement, this online interactive map would be accompanied by a printable list of steps necessary to get culverts replaced.

Intersections of Streams and Streets

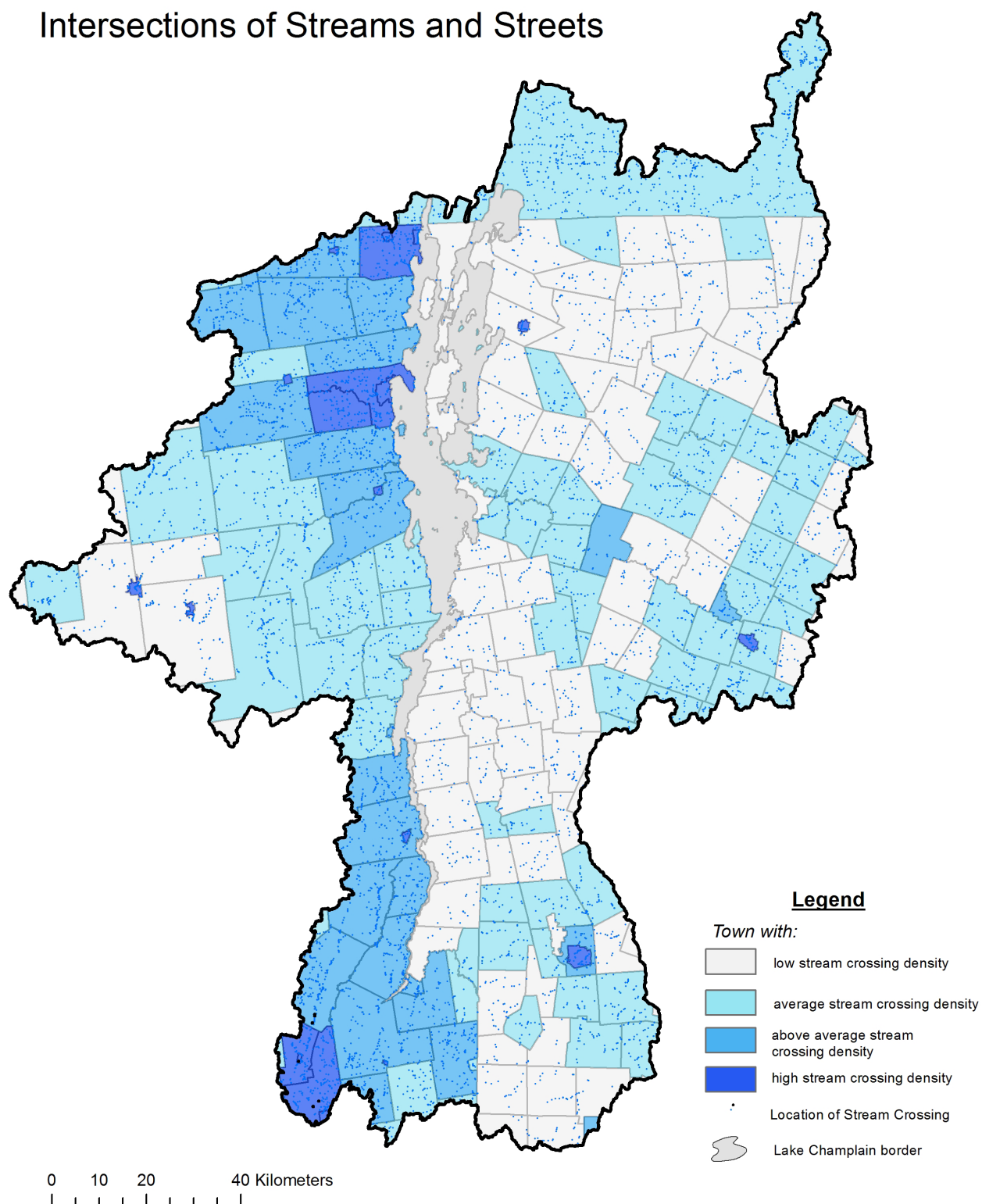


Figure 3. This map shows the intersection of all streams and road networks in the Champlain Basin to give an idea of what the Champlain Basin online culvert interface might look like at the zoomed out level. For a list of steps used to create this map, see Section 9.4 Technical Appendix.

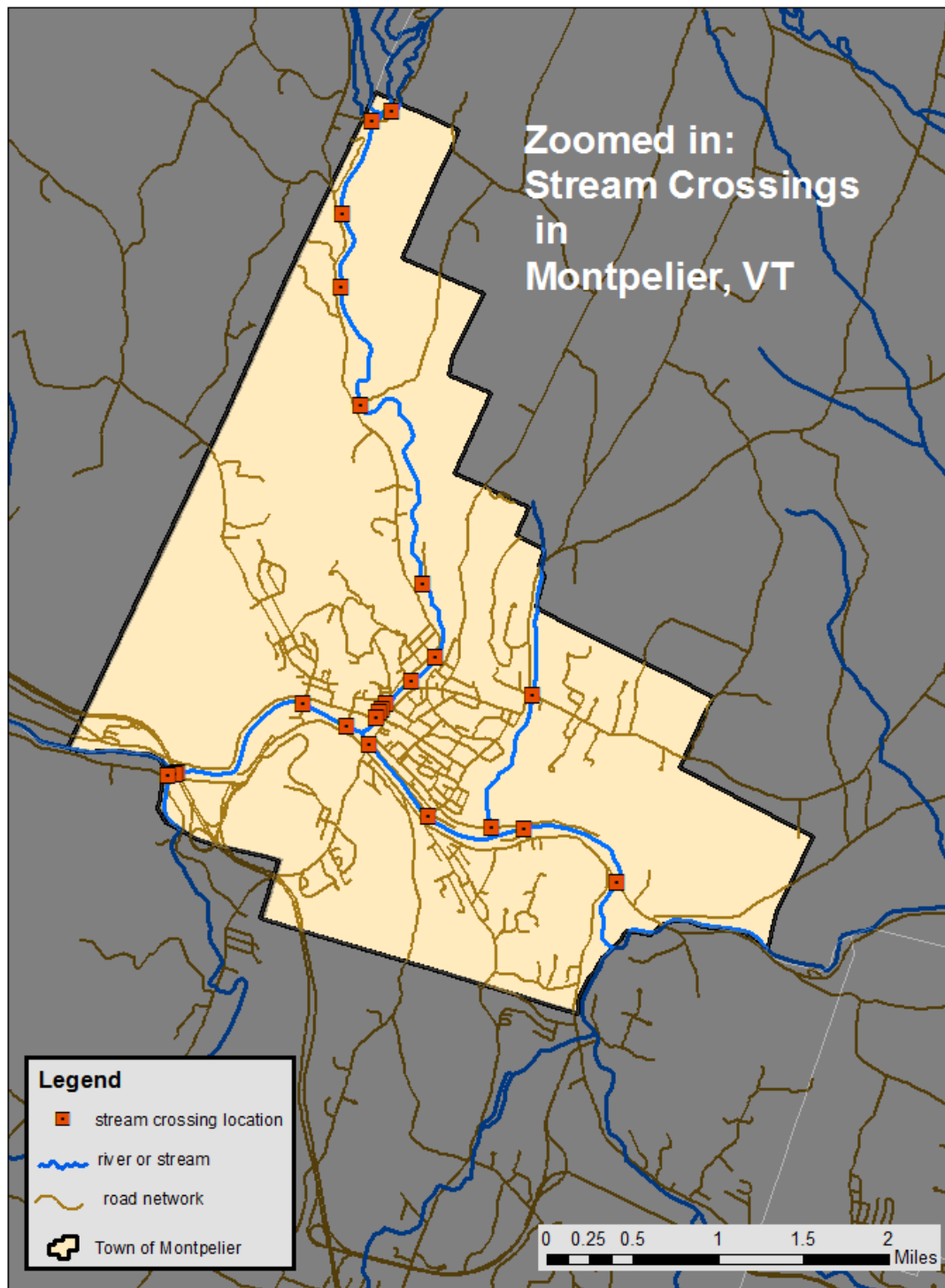


Figure 4. This map pinpoints the culvert locations in Montpelier, Vermont to provide an example of what the Champlain Basin online culvert interface might look like when the web user zooms in to view their respective town. For a list of steps used to create this map, see Section 9.4 Technical Appendix.

6. Facilitating Communication & Collaboration

In order to better frame the issue to stakeholders and to ensure that information is easily accessible to all, particularly publicizing the fact that promoting connectivity is a cost-efficient venture, it is necessary to look at the existing organizational framework in Québec, New York, and Vermont. Often, a few more emails and interdisciplinary meetings can generate a collective understanding that would otherwise be lost. These actions don't require more funding, but do require a redistribution of time to ensure that all stakeholders have a say in their areas of interest. From there we can draw general recommendations to aid better collaboration among stakeholders.

6.1 Current Framework and Communication Recommendations for New York and Vermont

Culvert replacement projects bring together a slew of stakeholders in Vermont and New York. Trout Unlimited, which works to improve connectivity for trout, is one primary stakeholder in this process and typically spends between \$50,000 and

\$250,000 on each culvert replacement project (Lawson, MacCartney, and Norton 2013). Municipalities and private interest groups thus look for opportunities for cost sharing on connectivity projects. We will examine how municipalities, private interest groups, and environmental agencies in Vermont and New York gather funds and collaborate with each other to lessen the cost burdens on individual groups.

Municipalities

While town taxpayer money funds the repair and replacement of smaller municipal culverts, larger culvert replacement and enlargement projects require the assistance of state and federal grant programs. These grant opportunities are through agencies such as the state and federal Departments of Transportation (Hazzard 2013).

Environmental Agencies

The Partners for Fish and Wildlife Program (PFWP) is the private lands arm of the Fish and Wildlife Service (FWS). Recognizing that the majority of US land is under private ownership, PFWP offers technical and financial assistance to private landowners to encourage the protection and improvement of habitat for certain species. In Vermont, one of PFWP's strategies is focused on improving stream connectivity to improve habitat for brook

trout. The program works with Vermont towns to replace or retrofit culverts that impede fish passage. PFWP is funded by the FWS, and also receives funding from the National Fish Passage Program and the Eastern Brook Trout Joint Venture, a partnership of state and federal fish and wildlife agencies, academic institutions, and private conservation organizations funded by the National Fish Habitat Action Plan (Eastern Brook Trout Joint Venture 2013; Smith 2013). PFWP collaborates with towns and offers resources to help replace culverts that have been identified as barriers to fish passage (Smith 2013). Chris Smith of PFWP notes that towns are willing to collaborate when such replacements also financially benefit the towns, which is often the case because culverts that are problematic for fish passage are also often constant maintenance problems for towns.

Private Interest Groups

There are a number of private environmental interest groups concerned with improving freshwater connectivity, including The Nature Conservancy and Trout Unlimited (TU). Private groups gather funds for culvert replacement projects to improve connectivity through a number of different sources. For example, TU often seeks funding through federal grants, which usually have match requirements, so TU turns to other smaller non-federal

funding sources to raise the remaining money. These include state funds, mitigation and enhancement funds (such as the Upper Connecticut River Mitigation and Enhancement Fund), the Eastern Brook Trout Joint Venture, private foundations, and occasionally individual donors (Lawson, MacCartney, and Norton 2013).

Vermont and New York have a large number of disparate entities that influence freshwater connectivity. We recommend the formation of statewide steering committees focused on this issue to consolidate the process. Our research has shown that there is redundancy in the existing framework, where one agency will work towards culvert prioritization in a watershed that is already being worked on by another agency. Both Vermont and New York do not lack the manpower or the will for freshwater resilience implementation, but the current process is inefficient due to a lack of communication. Ideally, these steering committees would include members from all governmental and private tiers of the state. Vermont's steering committee, for example, would host members from The Nature Conservancy, Trout Unlimited, PFWP, VTDEC, VTDOT, the Vermont River Conservancy, the state senate, and the Vermont Land Trust. This steering committee could meet on a biannual basis to prioritize action and discuss progress in the various sectors. We believe that this process is necessary within each state.

6.2 Current Framework and Communication Recommendations for Québec

Our findings suggest a lack of communication and awareness of the combined issue of freshwater connectivity and flood resilience currently in Canada. Christian Poirier of Transports Québec emphasized the necessity for stronger communication between different stakeholders to be more aware of the issues and the varying levels of interest between the different players. Similarly, only about half of municipalities (and thus road crews) are interested in the issue at all. There are some municipalities that are well aware of the issue regarding fish passage and culverts, but there are also those who are either unaware or do not have a concern for this issue. Furthermore, while there are laws at the municipal level, there seems to be a lack of enforcement (Nilo 2013).

To address this, we recommend a province-wide steering committee in Québec. This committee would function much the same as the committees in Vermont and New York, and it would serve as a platform to bring local municipalities and ground level stakeholders up to speed with regulations and best management practices.

6.3 Transboundary Communication

The natural environment knows no political boundaries, and in our increasingly connected world these issues are critically important. A fish swimming North through the Lake Champlain Basin does not remain in one state or even one country, and for this reason we need to diligently integrate policies in both Canada and the States. In the realm of freshwater connectivity, the communication between organizations in the U.S. and Canada remains unorganized and occurs on an ad hoc basis. Many of our interviews supported this generalization. Stakeholders would mention that they need to communicate with others across borders, but often this communication was low priority and late in coming. For this reason, it is important that the steering committees mentioned in the above section also designate subcommittees that can meet across state and country lines. These subcommittees will form a transboundary steering committee that can try to maintain an open communication line and offer recommendations to all three jurisdictions to improve freshwater connectivity and resilience efficiently.

The EPA, TNC, and the Association of Clean Water Administrators (ACWA) have jointly signed a memorandum of understanding (MOU) that formalizes a mutual collaboration between these groups to develop and implement healthy watersheds

programs. The EPA, TNC, and ACWA agree to meet periodically to track progress related to developing and implementing healthy watersheds programs across states, as well as promote the sharing of educational and scientific information. A similar situation, in which representatives from key stakeholder groups in NY, VT, and Québec meet periodically to discuss plans, could prove especially helpful.

There have been some cases of transboundary collaboration on freshwater connectivity in the region. For example, PWFP often communicates and partners with groups in New York, including the New York Department of Environmental Conservation, the Department of Transportation, and TNC. However, there is a lack of collaboration with Québec stakeholders, attributed to differences in priority trout species. While Vermont focuses on protecting brook trout, Smith claimed that there is little habitat for brook trout in the Richelieu region. Brook trout require cool water, and southern Québec's developed agricultural landscape has reduced shade and contributed to warmer water. As a result, PWFP has not prioritized working with Québec organizations to improve brook trout habitat.

Accordingly, Jack Imhof and Silvia D'Amelio from TU Canada have stated that a transboundary steering committee had been put in place but was found not to be effective in the past. However, Imhof and D'Amelio envision having representatives

or liaisons from each steering committee, both from the U.S. and Canada to meet and discuss these issues. Nevertheless, foremost, they emphasized the importance of communicating as the reason why there needs to be the creation of a committee so that people are convinced and thereby engaged in the issue. As they have stated, some incentives include efficiency, money savings, economic improvements, and environmental benefits. As a tool for future change, they have stressed that it is necessary to show people what change is going to be made with the implementation of a certain project. It is difficult for people to be convinced and supportive of an issue if there is not concrete evidence that a certain method will be successful or not. It is important to involve those at the ground level to utilize the tools that are already set in place, and then implement them. As Chris Smith of PWFP stated, he has not observed an increased interest in improving flood resilience at the town level, and does not believe that Tropical Storm Irene has significantly changed how towns are designing and installing culverts. As town select boards are responsible for directing the town's tax resources for public works, the costs and budgets remain the bottom line. Therefore, PWFP has focused efforts on bringing the ecological and flood resilience perspectives into town decisions about rebuilding.

As noted by TU Canada, it is important to have both the public and private sec-

tors discuss with each other regarding the issue of improving not only infrastructure for human needs but also freshwater connectivity for biological conservation. In regards to outreach to the general public, it is important to be able to show what the specific project will accomplish.

6.4 Communication & Collaboration: Final Words

We hope that statewide and transboundary steering committees can improve the efficiency of communication among stakeholders, and promote scenarios where Québec, Vermont, and New York are working towards common goals in freshwater connectivity. We know that transboundary communication is on the radar of many organizations. In May 2013, The Nature Conservancy held a meeting between its Vermont, New York, and Québec chapters. We hope that more agencies will take a cue from TNC and develop strategies to work together and collaborate on this transboundary issue.

7. Improved Policy Implementation

In addition to framing the issue of freshwater connectivity comprehensively and improving communication and education through a transboundary steering committee and dissemination of accessible information, we recommend improved implementation at the municipal level of policies and standards related to connectivity that are already in place. In Vermont and New York, we have concluded that this requires greater state oversight and guidance to municipalities to encourage culvert replacement and improvement projects. In Québec, we have identified the Fisheries Act as a potentially powerful and effective tool to mobilize stream-crossing improvements if it is better implemented and enforced at the municipal level. We believe giving towns in the region greater support and incentives to comply with existing standards and policies will encourage more culvert improvement projects that facilitate freshwater connectivity.

7.1 Vermont and New York: Improved State Oversight and Guidance

Vermont and New York have both demonstrated a commitment to freshwater con-

nectivity through their adoption of stream crossing guidelines and standards. The Departments of Environmental Conservation (DEC) in both states issue permits for stream alteration activities. The NYDEC has issued best management practices for stream crossings, and the VTDEC and the VT Agency of Natural Resources (VTANR) outline stream crossing standards in a Stream Alteration General Permit. In addition to ecological concerns, the two states are motivated to improve freshwater connectivity in order to be eligible to receive maximum reimbursements from the Federal Emergency Management Agency (FEMA) in the case of a severe weather event. Vermont was motivated to modify its stream-crossing permit process and standards after Tropical Storm Irene in 2011 and a decision by FEMA that Vermont was not eligible for certain reimbursements because its stream-crossing standards were not uniformly applied (“Gov. Shumlin...” 2013). Vermont issued a draft Stream Alteration General Permit in March 2013 in an effort to improve culvert standards and streamline the culvert repair and replacement process (Kline 2013). As discussed earlier, since 2011, some towns in Vermont have sought to improve and enlarge culverts destroyed by the storm to increase future flood resilience with the support of FEMA funds supplied after the town of Townshend appealed FEMA’s initial refusal to pay for culvert upgrades (“Gov. Shumlin...” 2013). New York and

Vermont permitting processes and stream crossing guidelines and standards indicate that both states seek to improve freshwater connectivity.

However, cost remains a major barrier to municipalities initiating culvert improvement projects to comply with state stream-crossing best management practices and standards. Therefore, municipalities in NY and VT require greater state oversight and guidance to encourage that towns take advantage of grant opportunities and cost-sharing programs to comply with state guidelines and standards. At the town level, we have identified that towns see little economic incentive for culvert replacement projects to improve flood resilience or aquatic fish passage before the culvert has been destroyed or is in poor condition. For municipalities, the costs and budgets are the bottom line, and if the town does not perceive an economic benefit of installing an upgraded, more expensive culvert, it is not likely to do so (Smith 2013).

While town taxpayer money funds the repair and replacement of smaller municipal culverts, larger culvert replacement and enlargement projects require the assistance of state and federal grant programs. These grant opportunities are through agencies such as the state and federal Departments of Transportation. The New York State Department of Transportation (NYSDOT) and the Vermont Agency of Transportation (VTrans) receive funding from the US Department of Trans-

portation that can provide financial support for projects that improve transportation infrastructure. These funding opportunities include Statewide Transportation Improvement Programs (STIPs), which are multi-year statewide transportation projects that are proposed by the state for federal transportation funding (“STIP Narrative” 2010; “STIP” 2013).

In addition, state Departments of Environmental Conservation (DEC) have grant programs to improve watershed and ecosystem health, for which some culvert improvement projects may qualify. In Vermont, these include Ecosystem Restoration Projects and Vermont Better Back Roads Grants (“Grants and Loans Program Summary” 2004). In New York, culvert projects that seek to restore aquatic habitat for wildlife may be eligible for the Water Quality Improvement Project Program (“Grant Applications” 2013).

Furthermore, the Partners for Fish and Wildlife Program (PFWP) often partners with municipalities to replace or retrofit culverts that impede fish passage. PFWP receives funding resources from various groups and collaborates with other agencies on connectivity projects, including the Vermont Fish and Wildlife Department, Trout Unlimited, and local watershed groups. Chris Smith at the VT Partners for Fish and Wildlife Program explained that while aquatic species protection is not usually a priority for towns, towns are receptive to projects that reduce the costs of

culvert maintenance and repair, especially if PFWP can offer some funding resources to reduce the cost burden of replacement on the town (Smith 2013). Please refer to Figure 5 at the end of Section 7 to see a sample flow diagram of funding in Vermont.

While there are a variety of cost-sharing opportunities for culvert replacement projects, funding is very limited, the grant process is long and onerous, and grant opportunities for towns only arise every few years. In addition, there are wide discrepancies among towns in terms of access to resources and support. While larger, more affluent towns have the resources to employ professionals to apply for grants and work on connectivity issues and may have taxpayer support for culvert improvement projects, smaller towns often do not have the resources to make stream-crossing improvement a priority (Hazzard 2013). Dale Hazzard of the Middlebury Public Works Department recommended that there be increased state oversight and guidance in the grant process, especially for smaller towns, to ensure that all towns have access to cost-sharing opportunities and that grant funds are employed to install improved culverts that facilitate freshwater connectivity. We envision this support taking the form of state aids or liaisons to towns that can encourage municipal culvert improvement projects by providing guidance for identifying and taking advantage of cost-sharing opportunities, and by

offering strategies and recommendations to help towns comply with state standards and guidelines. We believe that such state oversight and support could motivate municipalities to give greater priority to improving its culverts for ecological health and flood resilience.

7.2 Québec: Improved Implementation of Stream-Crossing Policy

As previously discussed, we have identified the Fisheries Act in Canada as a potentially effective tool for improving freshwater connectivity in Québec. However, thus far, efforts to implement the Fisheries Act to promote connectivity have been largely ineffective. Pedro Nilo, a biologist working for the federal Department of Fisheries and Oceans, notes that “on paper” the law gives the government the authority to force the removal of culverts impeding fish access, but this rarely translates to efficient enforcement. A lack of funding and human resources dedicated to this issue on both the federal and provincial level means that it is very difficult to maintain the expectation placed on those responsible for upgrading culverts, private landowners especially. Nilo notes that there is no program in place that specifically focuses on culvert replacement, although money allocated to stream crossings flows from the federal government to provincial governments to distribute as they believe

appropriate. In many cases, Nilo explains, a culvert will not be reviewed and discovered to be problematic for fish passage until it has been in place for years, and sometimes decades. In these cases, the landowner is often reticent to change the culvert, and/or financially unable to do so, and the local government devotes its attention to other concerns rather than enforcing the Fisheries Act to its full extent (Nilo 2013).

At its core, it seems, the problem stems from a lack of education and ownership of the Fisheries Act at the local level. Trout Unlimited Canada's Jack Imhof drew attention to a success story that may offer some insight for improving implementation. In 1991, Ontario successfully changed how the province repaired and installed large spans across rivers (i.e. small bridges). Scientists and engineers from both the provincial and county level formed a research team that compiled the data and wrote the proposal. This collaboration produced a multi-level team who understood both the science and implementation of such changes, and the local municipalities that participated were motivated to enforce these new policies since they had been part of the process of making them (Imhof 2013).

We recommend a similar process to encourage better implementation and enforcement of the Fisheries Act in Québec, or the formation of alternative policy or standards specifically applying to stream

crossings. We hope that the recommendations discussed above of comprehensive framing of the issue, the formation of a transboundary steering committee, and access to "easy" information can leverage greater interest and support for the issue of freshwater connectivity in Québec. We recommend that such increased interest be utilized to form a team of stakeholder representatives to develop strategies to employ the Fisheries Act to promote freshwater connectivity. By involving stakeholders in both understanding the policy and strategizing its implementation in the context of stream-crossing improvement, we believe that more groups and individuals will be motivated to enforce and comply with its specifications. Alternatively, stakeholder discussions may conclude that new policy or standards are required to adequately address freshwater connectivity, and a stakeholder collaborative process could be used to research and develop such policy.

We conclude that while Vermont, New York, and Québec have standards, guidelines, and policies that directly or indirectly address freshwater connectivity, municipalities are not adequately motivated to comply with such initiatives. Culvert improvements in Vermont and New York towns are mainly discouraged by cost, and improved state oversight and guidance to towns to identify and effectively utilize cost-sharing opportunities to improve culverts is needed. In Québec, lack of effec-

tive implementation of the Fisheries Act, the only policy related to stream-crossings, gives little incentive for towns to enforce or comply with the provisions. We recommend a stakeholder task force that collaborates to identify strategies to enforce the Fisheries Act to improve freshwater connectivity, or to draft new policy that addresses the issue directly. Only if such state and provincial guidelines and policies are effectively implemented and enforced can they work to promote freshwater connectivity in the region.

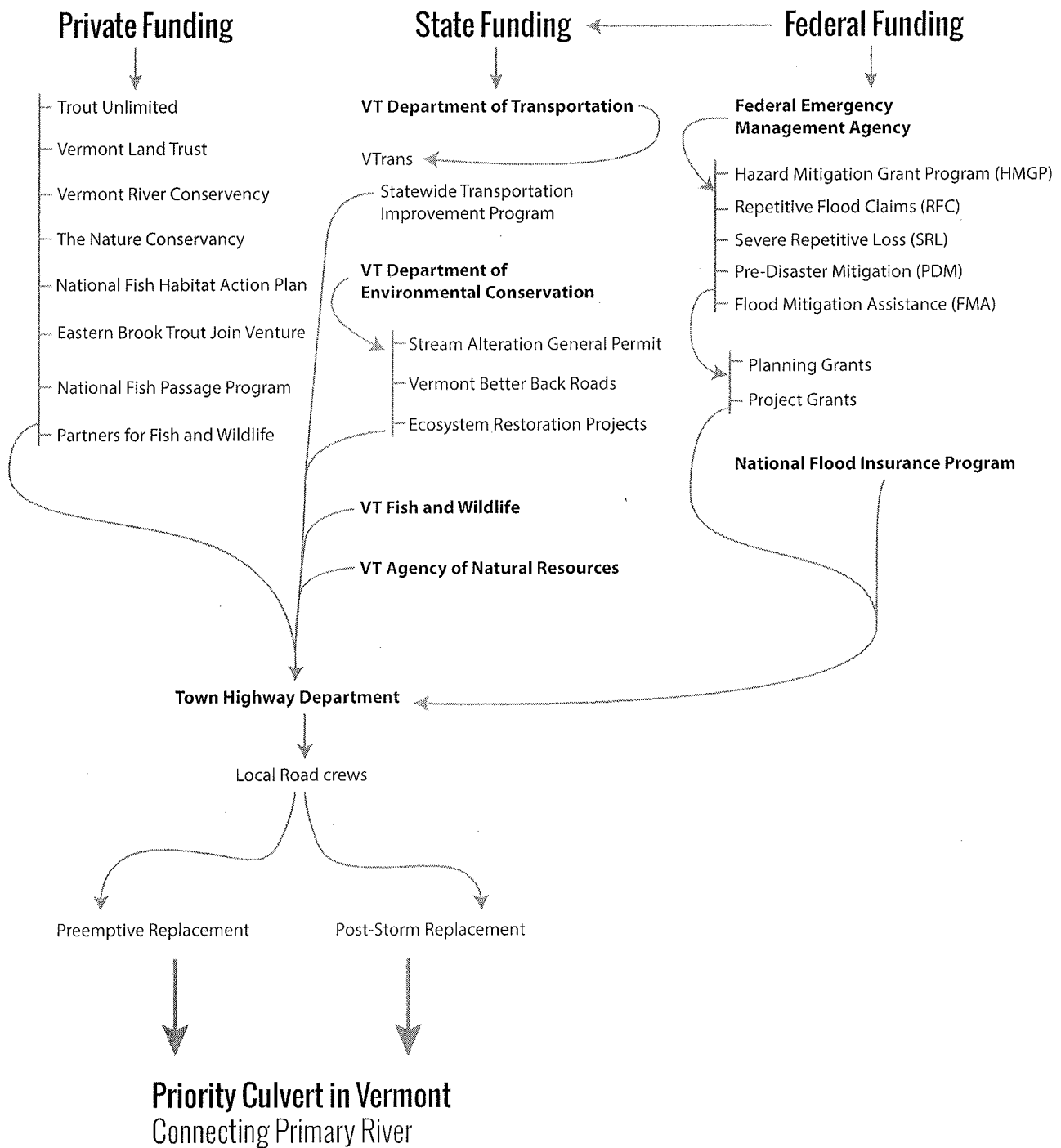


Figure 5. Above is a sample flow chart to outline how Vermont funding processes generally proceed.

8. Conclusion

Fontinalis happily makes her way through the stream as she passes the smooth scales and orange speckles of her fellow brook trout. Together they have returned to the place where they were born, where they will release their eggs, translucent and white against the flowing current, which will be embraced by the streambed. Frenzy arises as the males arrive and demand attention. Ahead lies a tunnel, and the brook trout feel the slight tug of pressure as they readily submit to the natural increase in flow. They find themselves in the dark tunnel, but move forward with their natural course of travel. Dark, yet familiar, the tunnel marks the passage into a slightly new sort of setting as they burst through into a surge of white light. Now they are back in a calmer stretch of the stream and can continue their journey. Soon they will reach their destination unhindered, and even in heavy rain, the stream will flow under the road according to its natural patterns, allowing the built infrastructure and the freshwater network to intersect in harmony.

This report has provided an overview of the necessary steps to take regarding the issue of freshwater connectivity and in order of the most easily implemented in a specific time frame. This report out-

lines an overall summary of the already-existing framework in the three different jurisdictions of the Lake Champlain Basin: Vermont, New York and Québec. As aforementioned in the introductory section, the built landscape intersects with the natural environment as they are closely entwined. Freshwater connectivity involves impacts relating to humans, the infrastructure that we build, and the environment in which we live. By assessing the pre-existing framework, based on our preliminary research, case study interpretations and the information that various stakeholders have provided us with, we have identified the gaps in these approaches between the different jurisdictions. According to what stakeholders throughout the Lake Champlain Basin have said about what is working as well as what has not been the most effective for preserving both ecosystem health and infrastructural networks alike, we have conducted a more comprehensive system of evaluation. Our findings have resulted in several opportunities to improve this framework with recommendations for future policy, economics, and educational outreach as discussed above. We have presented four core recommendations for the hopes of improving freshwater connectivity in the Lake Champlain Basin. Our first recommendation calls for a more comprehensive framing of the specific issue of freshwater connectivity so that all stakeholders are well aware of the issue at hand. Second, we recommend better

education about the issue at various levels through the dissemination of “easy” information and the formation of a basin-wide culvert inventory. Our third recommendation focuses on improving transboundary communication through the formation of steering committees in order to increase collaboration and leverage more resources for connectivity projects. Lastly, we recommend improved implementation of current standards and policies relevant to freshwater connectivity across the jurisdictions of Vermont, New York, and Québec. We hope our recommendations will be used to improve policy and expand public outreach efforts in the future in a collaborative transboundary effort to deal with the issues of stream connectivity and flood resilience in the Lake Champlain Basin.

9. Appendices

9.1 General Methods

In preparing this report, we have gathered information and useful knowledge from various sources. As a group of five students in a Senior Environmental Studies capstone course, we were presented with the topic of transboundary issues in sustainability. Our specific project involved freshwater connectivity as it crosses borders with both ecological and human concerns. Jessica Levine, our community partner, from the Adirondack Chapter of the Nature Conservancy had visited our class as we tried to decide the topic of study. Five of us chose to pursue Regional Freshwater Connectivity for this semester-long project. Jessica Levine, provided us with various resources from the very beginning of our research, and our initial steps started with reviewing the work done in the Ausable watershed in New York by the Nature Conservancy's Adirondack Chapter. During this time, we set forth to identify the major stakeholders in Vermont, New York, and Quebec who are concerned with the issue of freshwater connectivity. These stakeholders ranged from those dealing with infrastructure as it relates to culverts as well as ecological groups such as Trout Unlimited. We then proceeded to contact these different groups via email and phone calls. Many

stakeholders expressed an interest in providing us information and communicating with us either by email, conference call, or in-person meetings. For most conference calls, all group members were present and we compiled our notes in either Google Docs or Dropbox. We discussed the new information that was provided and used this in our evaluation for the development of our project.

Accordingly, we have presented our findings in this complete report of what has worked and what has failed regarding the efforts in stream connectivity and flood resilience in the Lake Champlain Basin. With this information, we have put together broad and more specific recommendations for future improvements for a more sustainable outlook. Extracted from this, we then created a toolkit of best practices as an easy-to-access handout, which we hope will serve useful for all stakeholders.

Throughout this whole process, we have consulted with Jessica Levine via conference calls and email exchanges in order to touch base as she steered us toward the right direction. We completed several drafts that were extensively reviewed by our community partner, seminar class professors, and fellow classmates. All comments were taken into consideration for the revisions of our draft reports.

Below are more detailed descriptions of our methods in gathering information, in forming our economic analysis, creating

the cartographic portion of the project, and conducting interviews with various stakeholders throughout the Lake Champlain Basin.

Internet-based Information Acquisition

While our most valuable information was obtained through direct communication with stakeholders, we also obtained basic information indirectly through online research. Most of our preliminary information was obtained from online resources through our research as well as referenced documents that our community partner had provided. We pulled relevant information from the webpages of government agencies, nonprofit organizations, and private companies involved in river management and culvert replacement.

Communication with Stakeholders

Our communication with stakeholders was primarily through email; however, some stakeholders were available for phone interviews or in-person meetings. We initiated contact by either email or phone and prioritized conference calls with Trout Unlimited representatives and stakeholders in Canada (since information for this jurisdiction was less accessible online). It should be noted that there may have been issues regarding translation between our phone conversations and email exchanges.

Special Events

We attended two events that were relevant to the scope of our project. The first was the “Upstream-Downtown” Conference at the ECHO Center in Burlington on Monday, April 8. The second was a Stream Alteration Permitting public comment meeting in Montpelier, VT on Thursday, April 11. Both events provided us with helpful information regarding future direction for the issue of flood resilience as well as an insight into infrastructure management.

Qualitative GIS Analysis

To gather basic layers used for the qualitative maps, a series of maps of streams and roads in the state of Vermont as well as a map outlining the boundary of the Lake Champlain Basin were downloaded from the Vermont Center for Geographic Information (VCGI). Maps of streams in Canada and New York State and road networks in New York were obtained through contact with the Lake Champlain Basin Program Communications and Publications Coordinator. The map of roads in Québec was obtained from a map of all roads in North America located on the Middlebury College Geography Department server. Our primary GIS analysis consisted of merging the separate “roads” files from all three jurisdictions into a single road network file, then merging the three separate stream files into one,

and finally overlaying the two files to pinpoint where roads and streams intersect (that is, locations of culverts and bridges or, more broadly, “stream crossings”).

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9.3 Policy Appendix

The complex political, economic, and educational framework in the Lake Champlain Basin directly influences the freshwater connectivity of the area. Understanding this network of stakeholders and existing legislation allows us to recognize successful policies as well as pinpoint problem areas. This outline of the current framework in Vermont, New York, and Québec is synthesized in this section to help form recommendations that will improve trans-boundary freshwater connectivity. For legibility, we've divided our research by governmental tiers (Federal, State, and local), and by country (United States and Canada).

9.3.1. Legislation

At the broadest scale, the Clean Water Act and the Endangered Species Act provide far-reaching, large scope policies for watershed health from the federal level. These laws help set guidelines for federal and state programs focused on conservation.

Clean Water Act: The Clean Water Act (CWA) outlines a structure for regulating pollutants in US waterways, and it regulates the quality standards for surface waters, including water quality affected by connectivity failure. The skeleton of the CWA was enacted in 1948 and was amended and revised in 1972 under President Nixon.

Endangered Species Act: The Endangered Species Act (ESA) provides guidelines for the conservation of threatened and endangered plants and animals and extends to their habitats as well. The ESA requires federal agencies to ensure that actions they authorize will not be detrimental to the existence of any listed species or result in the destruction of critical habitat of that species. This law indirectly affects water quality in Vermont and New England since watersheds containing threatened or endangered species will fall under the ESA's purview.

9.3.2. Federal Programs

The U.S. government has a robust set

of programs with the collective mission of improving environmental health and promoting long-term sustainability. The following groups play the largest role in administering freshwater connectivity policy and enforcement of those policies. The roles of many of these agencies often are defined per a project basis, and as such the case studies are meant to illuminate examples of the federal programs' functioning. This doesn't mean that the agency is limited to functions specified in our examples.

Environmental Protection Agency (EPA):

The United States Environmental Protection Agency was created for "the purpose of protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress" (Introduction to Region 9 2013). Under the Clean Water Act, the EPA has implemented pollution control programs and has set water quality standards for contaminants in surface waters. The EPA offer a Supplemental Environmental Projects fund that is used to offset the runoff of water from municipal projects, and through this fund local municipalities can direct money towards connectivity improvement. Specifically, the supplemental environmental projects are defined as "environmentally beneficial projects which a defendant/respondent agrees to undertake in settlement of an enforcement action, but which

the defendant/respondent is not otherwise legally required to perform.”

U.S. Fish and Wildlife Service (FWS):

The United States Fish and Wildlife Service (FWS) is a federal government agency within the United States Department of the Interior dedicated to the management of fish, wildlife, and natural habitats. The mission of the agency reads as “working with others to conserve, protect, and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people” (Who We Are, 2013). Often, the FWS partners with state agencies in water quality and connectivity projects. Two specific programs that directly affect freshwater connectivity are the National Fish Passage Program and the National Fish Habitat Action Plan.

The National Fish Passage Program (NFPP) is a voluntary, non-regulatory initiative that provides financial and technical assistance in the removal or bypass of artificial barriers that impede the movement of fish and contribute to their declining numbers.

The mission of the National Fish Habitat Action Plan, on the other hand, “is to protect, restore and enhance the nation’s fish and aquatic communities through partnerships that foster fish habitat conservation and improve the quality of life for the American people” (National Fish Habitat Conservation Act, 2013).

Federal Emergency Management Agency (FEMA):

The primary purpose of FEMA is to organize the response to a disaster that has occurred in the United States that has overwhelmed local resources and state infrastructure. FEMA’s umbrella program, Hazard Mitigation Assistance Unified Guidance, offers funding for pre-disaster mitigation and improved repair after a disaster. Of the many government program possibilities for improved flood resilience, this program has the potential to offer the most financial aid. Please refer to section 4.2 for a complete breakdown of this program.

U.S. Army Corps of Engineers:

Maintains and constructs public infrastructure, with a focus on sustainable development and national security. The Army Corps of Engineers oversees many hydrologic projects, including dams and bridges.

U.S. Department of Transportation (USDOT):

The mission of the Department is to “serve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future” (About Us 2013).

USGS Biological Resources Division:

The scientists of the USGS study the landscape of the United States, its natural resources, and the natural hazards that threaten it. The organization has four major science disciplines, concerning biology, geography, geology, and hydrology. The USGS tracks and documents flooding throughout the United States and offers assistance during extreme weather events.

U.S. Department of Agriculture (USDA):

The USDA's scope encompasses runoff regulation and water usage. This is particularly important in farming communities in the Lake Champlain Basin.

9.3.3. State Programs: Vermont

Many state laws, permits, and state organizations affect Vermont rivers and lakes. Act 250 is one of Vermont's most influential laws in recent history, and it has sweeping consequences for conservation work. It requires that new building developments of a certain size comply with specific environmental, local, and regional criteria before receiving a building permit. Most of the projects affected by the law are: "1) projects of ten or more housing units by the same applicant within a five-mile radius or 2) subdivisions of ten or more lots of less than ten acres each. Developments of fewer than ten units or ten lots are exempt from the permit process... Act 250

also applies to nonresidential construction involving 1) ten or more acres in towns with zoning regulations and 2) one or more acres in towns without zoning" (Daniels & Lapping 2007, p. 502).

New development also must consider Act 250's 10 environmentally-based and community-based criteria for construction:

1. Evaluation of water and air pollution,
2. Assessment of water supply,
3. Impact on existing water supply,
4. Prevention of soil erosion,
5. Traffic consideration,
6. Educational services,
7. Municipal or government services,
8. Benefits of scenic and natural beauty, aesthetics,
9. Conformance with the capability and development plan,
10. Conformance with local and regional plans (State of Vermont Natural Resources Board 2006, pp. 11-15).

Bullet points 3, 4, and 10 are especially relevant to freshwater connectivity - new building projects are assessed for aquatic ecosystem health, which consequently results in structures farther off stream beds and in areas more resilient to flooding.

There are several permits in the state

that help local municipalities implement flood resilience and river connectivity. Most importantly, the Stream Alterations / Stream Crossings Structure permit protects against creation of flood hazards and damage to fish life. The permit also protects the rights of neighboring landowners and assures compliance with VT Water Quality Standards. As of April, 2013 this permit has undergone revisions that will allow quicker access to FEMA funding. Please refer to section 4.2 for more information.

Finally, several state entities exert a concerted effort to improve aquatic connectivity. The U.S. Department of Transportation (and its child organization VTrans) offers grants to local municipalities for culvert repair / replacement and associated road work. VTrans has statewide policies in place that outline best management practices for culvert and dam sizing and installation.

Vermont Fish and Wildlife act on the other end of the spectrum. Much like its federal parent organization, it manages ecosystem health and administers hunting and fishing licenses.

The Vermont Department of Environmental Conservation under the Agency of Natural Resources bridges the gap between biological restoration work and infrastructure resilience. Within the organization there is both the Ecosystem Restoration Program and the Watershed

Management Division. This wing of VT-DEC offers financial, political, and scientific support for local municipalities to implement resilient infrastructure strategies. Under this organization there have been successful programs such as Better Backroads and Vermont Local Roads. These offer financial aid and education for creating long lasting roads and river crossings during increasingly frequent extreme weather events.

It is important to note that freshwater resilience is directly affected by town size in Vermont. Occasionally the state performs a comprehensive culvert inventory (the last one was in 2006), and reports its findings to the town. The town is then responsible to replace culverts as it sees fit. For a town like Middlebury, this offers an opportunity for the highway division chief, Dale Hazzard, to plan culvert replacement and implement these changes. However, most smaller towns such as Ripton and Brandon don't have a full-time highway chief, and instead rely on a contractor to replace road crossings. This ultimately results in smaller townships avoiding the planning stages of the process and instead only working to replace failed culverts.

9.3.4. State Programs: New York

New York State has a similar set of laws and permitting procedures. Just as its neighbor state is rich with environmental organizations, New York is composed of

many agencies geared towards connectivity and aquatic conservation. The New York Department of Transportation (NYSDOT) deals with road construction and permitting. The New York Department of Environmental Conservation is the parent organization of NY Fish and Wildlife and the New York Natural Heritage Program, both of which support connectivity projects through grants and research.

And like Vermont, again the issues arise at the local level. Many smaller town governments don't have the manpower or funding to put energy into long-term plans focused on freshwater resiliency. New York is, in large part, privately owned. This causes its own issues since various easements and ordinances need to be implemented for projects on private land to commence.

New York State has multiple permits that are pertinent to this subject:

- A Protection of Waters Permit is required for any activity that disturbs a protected stream.

- NYSDOT General Permit for bank and channel stabilization activities for transportation related construction activities and for permanent and temporary placement of earth fill when such fill is related to the rehabilitation or replacement of an existing transportation facility.

- The Municipal General Permit GP-5-12-00 allows new installation, replacement, repair or maintenance of a single arch, box, elliptical or round culvert and associated headwall protection that involves stream bed/bank disturbance which totals less than seventy (70) lineal feet, provided the replacement or repair does not consist of slip-lining.

- Article 15 Protection Of Waters Permit for a range of activities, including placement of structures in or across a stream.

9.4 Technical Appendix ⁴

Figure 1. Champlain Basin Towns

1. We started off with 2 separate files of segments of roads in the US portion of the Lake Champlain Basin. We obtained layers of New York features from Ryan Mitchell, The Communications Coordinator at the Lake Champlain Basin Program. This file was called "newyorkrds.shp," a map of all roads in New York State. We obtained a file of roads in Vermont from the Vermont Center for Geographic Information (VCGI) called "Emergency911_RDS.shp."
2. We projected both files into the Geographic Coordinate System,

⁴ All file names are in quotations and all GIS tools are in italics. All maps were created using ArcMap 10.1 spatial planning software.

WGS 1984 Zone 18N using the tool Batch Project and named the outputs with their original name followed by “_proj.”

3. We merged the 2 US road files using the tool Merge.
4. We obtained a layer of road networks in North America from the Middlebury College Geography Department server titled “north_am_rds.shp” and cropped it to the extend of the Basin in Canada using the tool Clip and named the output “Canada_rds.shp.”
5. We used the tool Merge to combine all 3 road network files and named the output “all_roads_merge.shp”
6. We obtained the file “basin_towns.shp” from the Middlebury Geography Department Server: (\\splinter\data>>USA>>Regions>>Champlain Basin>>Administrative>>basin_towns) and added it to the map package.

Basin Program), 1 in New York (“NY_all_streams.shp,” also from Mitchell) and 1 in Vermont “WaterHydro_DLGSW.shp” from the Vermont Center for Geographic Information (VCGI).

2. We projected all 4 files into the Geographic Coordinate System, WGS 1984 Zone 18N using the tool Batch Project and named the outputs with their original name followed by “_proj.”
3. We used the tool Merge to combine all 4 files and named the output “all_streams_merge.shp.”
4. We obtained the file “LandLand-cov_LCLULCB01.shp” from the Middlebury College Geography server and used the tool Raster to Polygon to create a shapefile of the basin, which we called “basin_boundary.shp.”
5. We took the file “basin_boundary.shp” and projected it into the Zone 18N coordinate system using the tool Project and named the output “basin_proj.shp.”

Figure 2. Champlain Basin Rivers

1. We started off with four files of stream networks: two in Québec (“NHN_02OH001_1_0_HN_NLFLOW_1.shp” and “NHN_02OJ001_1_0_HN_NLFLOW_1.shp” both from Ryan Mitchell, the Communications Coordinator at the Lake Champlain
6. We used the tool Clip to crop the file “all_streams_merge.shp” by the boundaries of the Lake Champlain Basin and named the output “all_streams_clip.shp.”
7. We obtained the file “WaterHydro_LKCH5K.shp” which represented the boundaries of Lake Champlain,

from VCGI and added it to the map package.

Figure 3. Zoomed out Web Interface

1. We started out with 3 separate files delineating roads in the Lake Champlain Basin (see steps for Figure 1 to see how road files were merged and clipped), and 4 separate files of streams (see steps for Figure 2 to see how stream files were merged and clipped).
2. We used the tool Multipart to Singlepart on the files “all_streams_clip.shp” and “all_rds_clip.shp” so that all separate road segments were dissolved into one road feature, and all stream segments were dissolved into one stream feature. We named the outputs “all_streams_dis.shp” and “all_rds_dis.shp.”
3. We then used the tool Intersect to overlay the features produced in step 2 to pinpoint locations of stream crossings. We named the output point file “crossings.shp”
4. We obtained the file “basin_towns.shp” from the Middlebury Geography Department Server and used the tool Point Density on the output from step 3 within the boundaries of “basin_towns.shp” to produce the file “crossing_dens.”

5. We used the tool Reclassify to reclass the output from step 4 to Jenks natural breaks with 4 categories and named the output “reclass_dens.”

Figure 4. Zoomed in Web Interface

1. We used the output from step 3 in the steps used to produce Figure 3 (above) and selected by attribute “TOWN” for value “Montpelier.”
2. We exported selected features as a separate shapefile and named the output “montpelier_zoom.shp.”
3. We overlaid the files “basin_towns.shp,” “all_streams_clip.shp” and “all_rds_clip.shp” to show culverts in the context of road and stream networks as well as town boundaries.

9.5 Toolkit of Best Practices

Four Key Recommendations

1. Framing the Issue

Before they take action to solve a problem, stakeholders must fully understand it. For this to happen, those with access to information need to communicate it and frame the issue in a thorough and compelling way to make clear its dual effects on stream species and flood resilience.

A. Encompassing Environmental Perspectives: Vermont and New York

- Continue to increase efforts to improve flood resilience and storm event readiness
- Emphasize the positive environmental impacts of better culverts
 - Aquatic species passage
 - Preservation of recreational uses of freshwater, such as fishing
- Engage private interest organizations to work with municipalities
 - Example: Trout Unlimited
- Pool financial and human resources from different groups working towards the common goal of improved stream crossings
- Potentially consider the issue from the perspective of climate change readiness

B. Incorporating Human Perspectives: Québec

- Continue to promote freshwater connectivity for the sake of aquatic species passage
- Broaden understanding of the human benefits of improved stream crossings
 - Fewer road washouts and less risk of community fragmentation
 - Long-term economic gains from preventative measures
- Ensure that all municipalities, instead of only half, recognize what their communities can gain from improved crossings
- Research projects by the Department of Transport and other government agencies that focus on built infrastructure and its intersection with freshwater
- Leverage the growing concern for infrastructure resilience inspired by the 2011 Richelieu flooding events

C. Overall Goals for All Jurisdictions

- Refigure the dominant narratives that surround the issue to encompass both the human and natural perspectives
 - Emphasize mutual benefits of improved stream crossings
 - Not a “man vs. nature” scenario
- Form committees that are “transboundary” in their interests and constituents
- Increase the number of key stakeholders by making each aware of his own stake
- Look to The Nature Conservancy as a model of an organization working to promote both ecological and human interests through improving stream crossings

2. Improving Public Education

In order to implement a reframing of the issue in all three jurisdictions, it is necessary to ensure that information is easily accessible to all stakeholders through improved public education.

A. Municipal and Public Education

- Eliminating Cost-Efficiency Misconceptions
 - Preventive culvert replacement cheaper than routine maintenance and post-storm replacement despite common knowledge
 - Need to publicize this information to stakeholders
- Voluntary Incentives in the US
 - Need to shift from state level to town level

B. Increasing Access to “Easy Information”

- Transboundary Culvert Inventory
 - Need to build on inventory at VCGI
 - Prerequisite to culvert prioritization
- Online Interactive Culvert Map
 - Inspired by Ausable Watershed Culvert Map
 - Allow zoom-in by town
 - Can be used by municipalities or merely to get public engaged
 - Accompanied by cost-benefit projections by town
 - Accompanied by process to guide culvert replacement

3. Facilitating Communication & Collaboration

In order to better frame the issue to stakeholders and to ensure that information is easily accessible to all, particularly publicizing the fact that promoting connectivity is a cost-efficient venture, it is necessary to improve communication and collaboration among stakeholders.

A. Current Framework and Communication Recommendations for New York and Vermont

- Municipalities
 - Geared towards storm resilience and infrastructure health
 - Need to also focus on ecosystem health
- Environmental Agencies
 - Generally focused on ecosystem health
 - Should provide support for infrastructure resilience as well
- State Steering Committee
 - Representative stakeholders must collaborate
 - Provide a holistic approach via an interdisciplinary steering committee
 - Need a freshwater steering committee within each state

B. Current Framework and Communication Recommendations for Québec

- Provincial Level
 - Orient focus on infrastructure resilience
 - Improve communication with municipalities
- Quebec Steering Committee
 - Increase awareness through stakeholder meetings
 - Bring all parties onto the same page for best management practices
 - Provide ownership of the issue

C. Transboundary Communication

- Increase Transboundary Interaction
 - Create sub-steering committees
 - Provide scheduled meetings between the NY, VT, and QC subcommittees
 - Use the transboundary committee to increase communication throughout the Lake Champlain Basin

4. Improved Policy Implementation

We recommend that there is an improvement in the implementation of current standards and policies relevant to freshwater connectivity across the three jurisdictions of Vermont, New York, and Québec.

A. Improved State Oversight and Guidance: Vermont and New York

- Implement Best Management Practices
- Encourage towns to take advantage of grant opportunities and cost-sharing programs for culvert replacement
- Encourage Participation in improvement projects
 - Statewide Transportation Improvement Programs (STIPS)
 - Ecosystem Restoration Projects
 - Vermont Better Back Roads Grants
 - Collaboration with Partners for Fish and Wildlife
- Have state aids or liaisons to encourage and provide guidance for improvement projects in smaller municipalities

B. Improved Implementation of Stream-Crossing Policy: Québec

- Streamline implementation and enforcement of policies addressing freshwater connectivity
- Invoke the Fisheries Act to mobilize culvert improvements
 - Enforcement at the municipal level is key
- Create a team of stakeholder representatives to develop strategies for employing the Fisheries Act
 - Idea of a “stakeholder task force”
- Form alternative policies or standards specifically related to stream crossings

9.6 References

- “About Us | Department of Transportation.” Web. 20 May 2013. <<http://www.dot.gov/mision/about-us>>.
- “Community Culture and the Environment: A Guide to Understanding Sense of Place.” Environmental Protection Agency Office of Water. 2002. Washington, DC.
- Barton, Manson. Telephone Interview. 10 May 2013.
- Branch, Legislative Services. “Consolidated Federal Laws of Canada, Fisheries Act.” 29 June 2012. Web. 28 Apr. 2013.
- Castle, Stephanie S. et al. “Flood Resilience in the Lake Champlain Basin and Upper Richelieu River.” Lake Champlain Basin Program (2013): 93. Print.
- “Conception de ponceaux - Rendement hydraulique réel.” 1998. Transports Québec : Répertoire Des Projets de Recherche et Développement. Web. 1 May 2013. <http://www1.mtq.gouv.qc.ca/fr/projet_recherche/description.asp?NO_PROJ=R291.1P1>.
- “Drainage Act, R.S.O. 1990, c. D.17.” Last amendment: 2010, c. 16, Sched. 1, s. 2. Web. 10 May 2013. <http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90d17_e.htm>.
- Eastern Brook Trout Joint Venture. Web. 27 Apr. 2013. <<http://easternbrooktrout.org/>>.
- EPA. “US Environmental Protection Agency.” Web. May 2013. <<http://www.epa.gov/>>.
- “Fish Passage and Connectivity in the Ausable Watershed using GIS Prioritization and Field Assessment Tools.” Prepared for the Lake Champlain Basin Program by the Ausable River Association, Plattsburgh State University of New York, and the Nature Conservancy Adirondack Chapter. Dec. 2012.
- Fisheries and Oceans Canada, Québec Region. “Best Management Practices for the Design and Construction of Permanent Culverts Less Than 25 Metres.” Print. July 2010.
- “Flood Resilience in the Upper Lake Champlain Basin and Richelieu River.” Lake Champlain Basin Program. 2013. <<http://www.monroban.org/public/documents/outils/uploaded/qvkhzff5.pdf>>.
- “Gov. Shumlin: FEMA agrees to funding for flood-resistant culverts.” Vermont.gov. 22 Mar. 2013. Web. Accessed 27 Apr. 2013. <<http://governor.vermont.gov/newsroom-fema-culvert-decision>>.
- Government of Canada, Fisheries and Oceans Canada. “Contractor Fined for Convic-

- tion Under the Fisheries Act.” 26 Feb. 2013. Web. Accessed 20 May 2013.
- “Grant Applications.” New York State Department of Environmental Conservation. 2013. Web. Accessed 13 May 2013. <<http://www.dec.ny.gov/pubs/grants.html>>.
- “Grants and Loans Program Summary.” Vermont Department of Environmental Conservation. 2004. Web. Accessed 13 May 2013. <<http://www.anr.state.vt.us/dec/grants.htm>>.
- Hazzard, Dale. Personal Interview. 4 Apr. 2013.
- “Wisconsin: Helping Northern Pike Cross the Road.” The Nature Conservancy. Web. 7 May 2012.
- Imhof, Jack. Telephone Interview. 16 Apr. 2013.
- “Introduction to Region 9: Enforcement and Compliance Assurance US EPA.” Web. Accessed 20 May 2013. <<http://www.epa.gov/region9/enforcement/intro.html>>.
- Jackson, Scott, Alison Bowden, and Brian Graber. “Protecting and Enhancing River and Stream Continuity”. In Proceedings of the 2007 International Conference on Ecology and Transportation, edited by C. Leroy Irwin, Debra Nelson, and K.P. McDermott. Raleigh, NC: Center for Transportation and the Environment, North Carolina State University, 2007.
- Kline, Mike. Public Meeting on Revised Stream Alteration General Permit. 11 Apr. 2013.
- Kraft, C.E., D. M. Carlson, and M. Carlson. 2006. “Brook Trout (*Salvelinus fontinalis*).” Inland Fishes of New York (Online), Version 4.0. Department of Natural Resources, Cornell University, and the New York State Department of Environmental Conservation. <http://fish.dnr.cornell.edu/nyfish/Salmonidae/brook_trout.html>.
- Lawson, C., MacCartney, J., & Norton, J. Trout Unlimited. Telephone Interview, April 2013.
- Long, John. “The Economics of Culvert Replacement: Fish Passage in Eastern Maine.” Maine NRCS. January 2010. Web. Accessed 17 April 2013. <<ftp://ftp-fc.sc.egov.usda.gov/Economics/Technotes/EconomicsOfCulvertReplacement.pdf>>.
- Meffert, Douglas. “Upstream Downtown Symposium.” Public Symposium at ECHO Aquarium. 8 Apr. 2013.
- “Fish Passage and Connectivity in the Ausable Watershed Using GIS Prioritization and Field Assessment Tools.” 2012. Print.
- “Modélisation de la capacité de l’omble de fontaine à franchir les ponceaux.” 2012. Transports Québec : Répertoire Des Projets de Recherche et Développement.

- Web. 1 May 2013.
- “Multi-Hazard Mitigation Planning.” Federal Emergency Management Agency. Web. 29 Apr. 2013. <<http://www.fema.gov/multi-hazard-mitigation-planning>>.
- “National Fish Habitat Conservation Act, Congressional Sportsmen’s Foundation.” Web. 20 May 2013. <<http://www.sportsmenslink.org/policies/federal/national-fish-habitat-conservation-act>>
- “Natural Champions.” 2009. Conservation Ontario. Web. 13 May 2013. <<http://www.conservation-ontario.on.ca/>>.
- “New York Culvert Inventory: What Lies Beneath.” The Nature Conservancy. 22 February 2013. <<http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/newyork/explore/new-york-culvert-inventory.xml>>.
- Nilo, Pedro. Telephone Interview. 25 Apr. 2013.
- Pennsylvania Department of Education. “Brook Trout Life Cycle.” PA Trout in the Classroom. 2009. Web. 19 May 2013. <<http://www.patROUTIntheClassroom.org/pdf/TIC%20Life%20Cycle%20poster.pdf>>.
- [Press Release] Peter Shumlin: FEMA agrees to funding for Flood-resistant culverts.” 22 March 2013. <http://governor.vermont.gov/newsroom-fema-culvert-decision>
- Poirier, Christian. Telephone Interview. 15 April 2013.
- “River Corridor Planning, Protection and Restoration.” VT DEC Water Management Division. 2013.
- Rouse, Katherine. “FTA Warns NJ Transit of Flood Risk.” The Record. 25 December 2012. <http://www.northjersey.com/news/Report_warned_NJ_Transit_officials_of_flood_risk.html?page=all>.
- Smith, Chris. Telephone Interview. 10 Apr. 2013.
- Stack, L., MH. Simpson, and T. Crosslin. “The Oyster River Culvert Analysis Project.” 7 Mar. 2010 : n. pag. Print.
- “STIP.” Vermont Agency of Transportation. 2013. Web. 13 May 2013. < <http://vtrans.vermont.gov/about-us/stip>>.
- “STIP Narrative.” New York State Department of Transportation. Oct. 2010. < <https://www.dot.ny.gov/programs/stip/files/narrative.pdf>>.
- “Stream Simulation: An Ecological Approach to Providing Passage.” Forest Service Stream-Simulation Working Group. May 2008.

“Vermont, FEMA Clash over New Culvert Funding.” Burlington Free Press. 7 Feb. 2013. Web. 27 Apr. 2013. <<http://www.burlingtonfreepress.com/viewart/20130206/NEWS07/302060035/Vermont-FEMA-clash-over-new-culvert-funding>>.

“Vermont Governor’s Awards for Environmental Excellence.” VT DEC Environmental Assistance Office. 2013. Web. Accessed 1 March 2013. <<http://www.eaovt.org/gap/index.htm>>.

“Who We Are.” US Fish & Wildlife Service. May 2013. Web. <<http://www.fws.gov/who/>>.